

STARTING SCHOOL EARLIER AND STUDENT PERFORMANCE:

A BRAZILIAN CASE STUDY

By

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1 INTRODUCTION

Education is becoming increasingly important in society and is often seen as one of the key factors in helping developing countries to prosper. At school, children learn an array of basic mental, social and cognitive skills to prepare them for the job market and their roles as citizens.

In many cases, education reforms are necessary to better accommodate and optimize children's learning. Some of the most important changes found in educational reforms are related to school starting age. Changing school starting age implies major changes in households as well as in schools: teachers must adjust their curricula, schools the size and number of their classrooms, and parents their working schedule. Thus, it is very important to investigate children's optimal school starting age.

A recent Brazilian educational reform gives us a rare opportunity to attempt to answer this question. In 2005, Brazil launched its educational reform (*Ensino Fundamental de Nove Anos*, literally fundamental 9 year education), whose main objective was to change school starting age from seven to six. Almost ten years later, we can examine some of its impacts since whole cohorts affected by the reform have gone through the education system.

While in most countries children start school at age six,¹ Brazil presents us with a unique occasion to compare the potential benefits of current practices versus starting school at older ages. The reform is expected to improve children's learning, among other objectives.² Indeed, grades and academic success rates could potentially rise since children will have had more time to build their cognitive skills.

In this paper, I focus on mathematics and Portuguese test scores as indicators of the academic effect of the reform. I use data from the state of Minas Gerais³ since other Brazilian states implemented

¹ For further data, see World Bank (2013).

² Parents that were taking care of their children at home can join the workforce one year earlier, children might be more inclined to respect authority if introduced to a structured environment earlier, children may stay longer in school, among other impacts.

³ Minas Gerais is one of Brazil's 26 states. Its population in 2010 was 19,597,330 compared to Brazil total population which was 190,775,199, see IBGE (2010)

the reform more gradually. Minas Gerais has the advantage of having a large population as well as a mix of urban and rural areas. I employ a differences-in-differences model to evaluate the impact of this reform. This strategy is often used in the economics of education literature.⁴

My results show that there was an increase in test scores in both mathematics and Portuguese that seems to be associated with the reform. This suggests that the Brazilian education reform did have a positive impact on children's test scores. It remains difficult to discern if this positive link between starting school earlier and test scores is related to students' starting at an earlier age or having had one more year of school. The results do show a positive trend potentially explained by these two factors. Throughout the paper, whenever I mention earlier school starting age I also imply the fact that the students have had an extra year of schooling. Further research should investigate other potentially affected variables such as dropping out rates, failing rates, crime rates, etc.

The rest of the paper is organized as follows. In Section 2, I present a literature review of related articles. In Section 3, I explain the data sources used and in Section 4 I describe the empirical strategy. Section 5 presents empirical results. In Section 6, I discuss some potential problems and in Section 7 policy implications. Section 8 is a conclusion.

2 LITERATURE REVIEW

Changing the age at which students start school is a rather uncommon policy since most countries have been starting school at the same age for decades. Most OECD countries have children starting primary school at age 6 (World Bank, 2013). However, there is still a debate as to whether this is or not the ideal age to start school.

The literature discusses both the positive and negative aspects of starting school earlier. Green and Simons (1962) started looking at the optimal age for a first grader. Using data from 4th graders in

⁴ Many studies evaluating educational reforms use a difference-in-differences model. See, for example, Cascio (2009), DeCicca and Smith (2011), and Baker et al. (2005).

public schools in Decatur (Georgia, US), they match school starting age with grades. They separate the kids into two categories: a younger class who started at age less than 6 and an older class who started at age 6 and up. They find a positive correlation between school starting age and test scores, but they mention the difficulty of calculating how much children starting at a later age had learned before starting school. To counter this issue they use a chronological age and mental age conversion for each student. They establish charts of what a student would score according to their mental age, chronological age, and school grade enabling them to "anticipate" a score and compare with the data. They found that starting school later might improve a student's grades, but that these improved grades were lower than current age norms grades.⁵ Later, Halliwell (1966) supports these observations by summarizing much of the school entrance literature of the time.

Similarly, DeCicca and Smith (2011) find that delaying school entrance may lower the probability of grade repetition as well as improve mathematics and reading test scores. They base their research on a British Columbia experiment where older children would start kindergarten in September and younger children would start it in January. The program was interrupted leaving some children in kindergarten for six months and some for sixteen months. This allowed them to compare the two cohorts of children using a difference-in-differences estimator. They found that students who had started later were less likely to fail a grade and had higher grades in both mathematics and reading. Their explanation for these results is that the time spent maturing outweighs the benefit of starting kindergarten early.

The ideal school starting age may be closely related to a student's intelligence scores: some authors argue that a brighter pupil could profit by starting school earlier (Black et al., 2008). One of the problems with evaluating ideal school entrance age is the fact that kids are only 6 years old once. That is, we can compare cohorts, but it is important to control for students heterogeneity. For instance, it is important to compare high IQ early entrants with high IQ late entrants. Failure to do this would only

⁵ These current age norm grades indicate the grades that student would have had if they had started school earlier.

prove that smart children starting earlier perform better than average students entering at the normal time (Halliwell, 1966), but the question of interest is how would these high IQ students have performed if they had started later.

The paper by Black et al. (2008) attempts to answer this question. They use panel data from Norway, where military enrollment is compulsory. The database contains information on school starting age, test scores and IQ test scores, enabling them to create predicting charts⁶ for students. Their findings support the idea that starting school earlier helps students score higher on test scores but that these effects might not matter in the long run. Indeed, they find no long term effects on earnings and education attainment related to school starting age.

Another related study observed that starting school later might be more beneficial for families who have a weaker educational tradition. Fredriksson and Öckert (2005) use data from Sweden, where school starting age is six or seven depending on the year the student was born. In Sweden, a student born in December and one born in January can have almost the same age, but be in different grades. Their paper uses OLS regressions with predicting charts to compare actual age and school age. Their findings do support the theory that starting school later enables the student to mature more and perform better on tests. However, starting school later also implies a negative opportunity cost: students starting later finish later so they enter the labor market one year later (Fredriksson and Öckert, 2005). The more recent literature highlights the importance of calculating factors such as student ability when judging test score performance (Cascio, 2009; Card, 1994).

In the case of Brazil, the education reform allows me to use the difference-in-differences model usually used in the literature to evaluate the impact of school starting age. Following the literature, I also take into account student socioeconomic data to better evaluate the age difference impact of the reform. The key is to try to clearly identify the difference in test scores that is explained by the

⁶ The predicting charts used here are much like the ones thought of by Green and Simmons (1962). Data is used to predict how a certain kind of student would perform depending on factors and then newer data with different school starting age is used in comparison.

difference in school starting age.

3 DATA

To evaluate the impact of the 2005 Brazilian reform, I use data from the Brazilian National Institute of Education.⁷ Started in 1995, this bi-annual public database is rich with information on many variables applicable to this research. The data contain national standardized exams scores (*Prova Brasil*), where students are evaluated on mathematics and Portuguese. These scores are standardized throughout the years so that one can compare the results from year to year. The tests are supposedly similar in difficulty and evaluate the same concepts and material. If a test is found to be too easy or too hard, marks are adjusted throughout the country.⁸ In addition, every student fills out a socio-economic questionnaire with information varying from how many cars the household has to the age of the student. Teachers and principals also fill in questionnaires referring to teacher qualifications, experience, and school quality and amenities. Thus, the data provide us with student scores as well as an assembly of potential explanatory variables (a more complete list of the variables used can be found in Appendix B).

Before the reform, the standardized exams tested the mathematical and Portuguese ability of 4th and 8th graders. These are two separate tests for each grade. As a result, students following a normal path (not failing or dropping out and restarting) passed these exams at age 10 and 14. After the 2005 reform, students started school at age 6 and took the exams at the same ages, but now in grades 5 and 9. The fact that different cohorts are the same age when tested allows me to better capture the impact of starting earlier but leaves me with the problem of not being able to disentangle starting early and having an extra year of schooling.

By choosing years 2007 and 2011, I am able to detect the effect of the reform since 5th graders in 2011 have started school at age 6 whereas 4th graders in 2007 have started school at age 7. I am also

⁷ Instituto Nacional de Estudos e Pesquisas Educacionais, for further information see INEP (2013).

⁸ The results for Portuguese and mathematics scores are scaled to a median of 200 and 50 standard deviations.

able to capture the longer term effects of time by using 8th graders in 2007 and 9th graders in 2011 as control groups, since between 2007 and 2011 students or grades might have improved over time.

I focus on Brazil's second most populated state, Minas Gerais. Minas Gerais is not in either extreme of the poverty scale when compared to the other states and it has a mix of urban and rural population much like Brazil as a whole.⁹ The main advantage is that Minas Gerais implemented the reform completely in 2005, unlike other states that did it gradually. Because of its sheer size (19 million people, or 10% of Brazilian population, and approximately 500,000 4th and 8th graders), the sample from Minas Gerais is large enough for the exercise at hand.

I also use other states that had not implemented the reform in 2005 as a control group. These states are Acre, Mato Grosso do Sul and Roraima. This allows me to further validate my results and makes a stronger case for my regressions.

As expected, some students did not fill out the questionnaires completely¹⁰ and so their answers were not used for the regressions. After having cleaned the data and matched students to their schools, I obtain 256,637 4th graders and 227,905 8th graders for 2007 (total of 484,542). For 2011, I obtain 265,764 5th graders and 213,177 9th graders (total of 478,941). I lose 229 observations due to Portuguese exam results missing and 325 observations due to mathematical exam results missing. For the 2011 database, I lose 2,098 observations due to missing exam results.

The choice of explanatory variables follows the literature. The database contains individual (student), school, and municipality information.¹¹ The student data allows me to control for gender, income (the student answers if he has a computer with Internet in his household),¹² quantity of Portuguese and mathematics homework done (no homework, some homework or all the homework). The data also has information on students having failed previous years and having dropped-out at some

⁹ For further statistical data on Brazil see IBGE (2010).

¹⁰ For example, if the box is not completely greyed the scantron can have problems or if two answers are greyed instead of one.

¹¹ I did not use the teacher data since in 2007 I did not have the information on what subject was taught by the teacher.

¹² A computer with Internet access is associated with a family with higher income in Brazil. (Ferguson et al., 2003)

point in their academic careers. This is key because of Brazil's academic reality¹³ and since it might affect test performance, even if the direction of the effect is a priori ambiguous. Drop-outs having restarted school might learn better since they are older or they might have trouble learning since they do not have a solid basis of academic knowledge (especially if the student dropped out for many years). Generally speaking, special attention is needed when analyzing children with age-grade distortion since the direction of the age effect can go both ways.

I also introduce school fixed effects, which control for time-invariant school heterogeneity. This allows me to capture more precisely the impact of the reform since some of the differences in the grade's scores might be explained by school quality. The underlying assumption is that school quality did not change much between 2007 and 2011.

Table 1 shows the evolution of these variables comparing 4th graders in 2007 to 5th graders in 2011. All variable means differ significantly at the 1% level in 2007 and 2011. The mean for mathematical test scores rose from 179,988 to 204,346 (13.5% increase). In the case of Portuguese test scores, the mean rose from 199,781 to 226,177 (13.2% increase). The percentage of students living in a household with a computer rose by 93%. The mean for the failing rate variable dropped by 17.9% and the mean for the drop-out rate variable dropped by 12.3%. Less 5th graders reported doing their homework as the mean for mathematical homework dropped by 2.3% and the mean for Portuguese homework dropped by 2.9%. The demographic composition of the student population changes slightly over the period with 49% male 4th graders in 2007 and 50.6% male 5th graders in 2011 (3.3% increase).

Table 2 presents the same variables, but compares 8th graders in 2007 to 9th graders in 2011. The results found are similar in the sense that the variables vary mostly in the same direction. When comparing the 8th graders to the 9th graders the mean for Portuguese results is on the rise by 7.1% and by 4.6% for mathematics results. The mean for the computer variable also shows a larger magnitude

¹³ Brazil is characterized by high drop-out and failure rates in both 2007 and 2011, and the drop-out rate is usually associated with children going to work (Cardoso and Verner, 2006).

rising 117%. The failing and dropping rate variables drop by 8% and 48.1%. The homework variables this time are on the rise with the mean for Portuguese homework going from 0.612 to 0.623 (1.8%) and the mean for mathematic homework going from 0.592 to 0.888 (50%). The student composition does not vary between the two groups with males representing 46.1% of students in both cases

4 EMPIRICAL STRATEGY

To estimate the impact of the Brazilian reform one could simply do a comparison of mean scores for the grades affected by the reform. This basic model would compare the average mathematics and Portuguese test scores of 2007 and 2011 for 4th and 5th graders. It is convenient to have both mathematics and Portuguese test scores since starting school earlier might have a different impact on learning in different subjects. One of the simplest ways to evaluate the reform:

$$\Delta R = U_{2011} - U_{2007} \quad (1)$$

where ΔR is the difference in scores and U_t ($t=2007,2011$) is average mathematics (or Portuguese) test scores for year t . This exercise would be valid if without the reform the differences in means between the two groups would be zero. Since this is not the case, using this method simply gives a biased idea of what I want to measure. Again, though this method is not precise, it does not serve the purpose of evaluating the effect of the reform as it is impossible to know whether the increase in the scores is due to a variation over time of the quality of the students or the level of difficulty of the test, any major changes influencing student performance other than the reform that happened between 2007 and 2011. Even if I were to introduce control variables in such a model, it would not be possible to dissociate the effect of the reform from a time trend.

Given the available data, we can better capture the effect of the reform by having a control group and a treatment group. I use 4th graders in 2007, 8th graders in 2007 and 9th graders in 2011 whom both started school at age 7 as control groups. This allows me to gauge how student performance

in the tests has changed over 4 years. I then assume that the trend of 8th and 9th graders would be the same as the 4th graders in 2007 and 5th graders in 2011 if it were not for the reform. The deviation from this expected trend can be attributed to the reform since the 2011 5th graders have undergone the reform and the 2007 4th graders did not. Since the time lapse between the cohorts is short I can assume to a certain extent that there is no major cultural or economical difference between the students. Thus, I expect the common trend assumption to be reasonably valid.

I built a simple model comparing the differences between 2011 9th and 5th graders to the difference between 2007 8th and 4th graders in either mathematics or Portuguese test scores. If the assumption of parallel trends were incorrect, usage of the difference-in-differences model would not make much sense. Consequently, the interpretation of the results found from these estimations depends strongly on this hypothesis. Each model is also used for Portuguese results and the variables change accordingly. The general model with school fixed effects and controls:

$$U = \beta_0 + \beta_1 \text{Age_10} + \beta_2 \text{Post} + \beta_3 \text{Age_10} * \text{Post} + \gamma X + \text{School} + \varepsilon,$$

where Age_10 is a binary variable for the different grades (4th or 8th in 2007 or 5th or 9th in 2011), Post is a binary variable establishing the difference between 2007 and 2011, X is a vector of controls, which includes computer in the household, if the student failed any academic years previously, if the student reported doing homework, student gender, school averages, municipal averages, and School is a school fixed effect.¹⁴ Some of these variables could have been affected by the reform. Controlling for them did not affect my results much.¹⁵

The coefficient of most interest here is β_3 associated with Age_10*Post (treatment variable). The treatment variable is a binary variable equalling to 1 if both Age_10 and Post are equal to 1 hence capturing the 5th graders in 2011 that have undergone the reform. The other variables are included to control for socio-demographic student characteristics that may affect their test scores.

¹⁴ In the full model the base case student is a 8th grader female from the 2007 cohort, who does not have a computer in her household, reports doing no homework and has not failed a year of schooling or ever dropped-out.

¹⁵ Adding the *Fail* variable or the *Homework Variable* changed the coefficient of the treatment variable by approximately 3%.

Lastly, I go further in the analysis by building a simple model using states that had not implemented the reform as control groups. The states Acre, Mato Grosso Do Sul and Roraima were used since in 2005 they had implemented the reform in less than 4% of their schools (Silva and Scaff, 2010). I estimate:

$$U = \beta_0 + \beta_1\text{Minas} + \beta_2\text{Post} + \beta_3\text{Minas*Post} + \varepsilon,$$

Where Minas is a binary variable indicating if the student is in Minas Gerais or one of the other states and Post is the same variable from the previous model separating 2007 from 2011. Once again the coefficient of interest is β_3 for Minas*Post (treatment variable) a binary variable equalling 1 if the student is from Minas Gerais and has been affected by the reform. It is to be noted that for this model I only use 4th and 5th graders and therefore do not have to assume that the trends of 4th/5th graders was similar to 8th/9th graders.

5 EMPIRICAL RESULTS

To understand the results and coefficients found in the regressions it is important to realize that the dependent variables are students' marks in mathematics and Portuguese test scores. If I had used all the data from Brazil my results would not have much meaning since they would only reflect the standard aimed for by the statistics institute. Since the scores used in the data are standardized at a national level, but I use data from one state, in this case Minas Gerais, this issue is not a problem and my results are valid.

The comparison of the means in Table 1 shows an increase in test scores that is significant at the 1% level between 2007 and 2008 for grades 4 and 5, respectively. The same holds for grade 8 and grade 9, as shown in Table 2.

The next step is to discuss the reform coefficients obtained after regressing using both mathematics and Portuguese test scores shown in Table 3 and 4. The following comparisons are always

done by comparing the various coefficients to the mean of the dependent variable (either mathematics or Portuguese test scores), which are presented at the bottom of Tables 3 and 4 or in comparison to standard deviations of the dependent variable.

In the first model without controls I get a one standard deviation decrease (mathematics) and a 1.07 standard deviation decrease (Portuguese) for the *Age_10* variable indicating that students perform better when in 8th or 9th grade compared to 4th or 5th grade. In the models where I introduce control variables, the coefficient strength drops slightly as can be seen in Tables 3 and 4. The estimate of the *Post* variable is positive (a 0.22 standard deviation increase for mathematics and a 0.31 standard deviation increase for Portuguese) meaning that students performed better in 2011 than in 2007 and more so in Portuguese than in mathematics. Due to the standardization, this result is in reality the performance of student from Minas Gerais with respect to the rest of the country. The variable of greatest interest is the *Age_10*Post* variable, i.e., the one that estimates the impact of the reform. The coefficient estimates are positive and statistically and economically significant for both mathematics and Portuguese regressions. I find 5.8% for the mathematics score and 3.1% for the Portuguese score hypothetically capturing the positive effect that could be attributed to starting school earlier. This is respectively a 0.28 standard deviation increase for mathematics and a 0.14 standard deviation increase for Portuguese. This means that not only did students in Minas Gerais perform better between 2011 and 2007, but also those subject to the reform, i.e., who started school earlier, experienced an even larger increase in test scores. As can be seen in column (2), the coefficient strength goes up slightly when I introduce school fixed effects, from 5.8% to 6.2% and from 3.1% to 3.5%. Furthermore, in column (3), where I add student controls, the coefficients drop to 4.8% (0.23 standard deviation increase) for mathematics and less than 1% (0.03 standard deviation increase) for Portuguese.

Thus, these results point to a positive relation between starting school at an earlier age and performance at school. Many hypotheses can be made here to try and explain the results. One of them is that learning in an academic environment is a process that gets easier as children are more exposed to

it. Taking notes in class or completing homework can become positive habits as students grow more accustomed to learning. Another possibility is that parents might have gotten more involved with their children's learning process since they were starting school earlier. It is important to link the results with the data. These results are relevant to the state of Minas Gerais and may to a certain extent generalize to Brazil. A similar study made in a different country could have very different results. That being said, this study is still an indicator of a positive link between school starting age and school performance.

The coefficient estimates for the other control variables vary in the same way as predicted by the literature. It is also interesting that most of them are quite similar between the mathematics and Portuguese regressions. They relate in generally the same way to the control variables (student drop-out, student failing, computer in household, etc). Having both subjects correlating the same way strengthens the idea that school starting age is positively related to student performance in Brazil.

The coefficient estimate for *Computer* is positive and statistically significant in both cases (a 0.13 standard deviation increase for mathematics, a 0.14 standard deviation increase for Portuguese). Having a computer with internet access in the household seems to positively affect a student's performance. In Brazil, a computer with internet access in the household is usually found in wealthier families (Ferguson et al., 2003) so this could be linked with wealthier students performing better. More thorough analysis would be needed to find if it is the wealth of the family or simply the fact of having a computer that is influencing student performance. That being said, I assume that some of the performance is related to wealthier families having the means of hiring tutors or just being more thorough with their supervision of the children's homework.

The *Fail* variable has a negative coefficient estimate, which indicates that students who have failed a year in school tend to have lower grades in following years. The regressions show coefficients representing a 0.49 standard deviation decrease for mathematics test score and a 0.44 standard deviation decrease for Portuguese test score. This effect follows the literature (Finn and Rock, 1997) in the sense that students who have failed previously are at risk of failing again (or getting lower scores),

especially in developing countries.

The *Drop-out* coefficient estimate is also negative showing a 0.11 standard deviation decrease for mathematics and a 0.09 standard deviation decrease for Portuguese. This is also similar to other papers in the literature and may reflect the fact that a returning student might have forgotten some of the material. For example, a 12 year old having dropped out at age 10 and 11 and then restarting might remember less well the mathematical or Portuguese notions that he learned before, diminishing his chances of getting a better grade on the ministerial exams. The coefficient is more serious for mathematics perhaps indicating that mathematics builds on earlier notions, and therefore it is highly important to remember the basics learnt in previous years. Alternatively, it could be an indicator of lower ability which would also explain lower scores on the ministerial exams.

Completing homework should be an important part of learning and the regressions show positive coefficients for both mathematics and Portuguese homework variables. Indeed, children need to learn at school and then revise concepts and do exercises at home to better understand the material. Thus, it is not surprising that the coefficients *Mat. Homework* and *Port. Homework* are statistically and economically significant. The homework variables coefficients represent a 0.24 standard deviation increase in test scores for mathematics and a 0.18 standard deviation increase for Portuguese. Interestingly, these variables might be linked to high ability student, which would also explain the higher test scores.

An interesting finding, but still in accord with the literature (Mau and Lynn, 2010) is the fact that male students seem to perform better in mathematics and female students perform better in Portuguese. This can be seen with the *Male* variable. The regressions indicate that other things being equal, males have test scores that are a 0.15 standard deviation higher in mathematics and a 0.2 standard deviation smaller in Portuguese than females. These findings could support certain policies.¹⁶

¹⁶ Knowing that boys perform better in mathematics on average and girls in reading might be a reason to have classrooms with a mix of genders so that stronger students can help poorer students (Telles and Lim, 1998).

Once again, the controlling variables are mostly used to narrow down the real impact of school starting age. The importance of gender in student performance on tests justifies the presence of such a control variable.

To further confirm my findings I use other states that had not passed the reform in 2005 as a control group. Table 5 and 6 show the results of regressions controlling if the student came from Minas Gerais or from 3 states with small percentages of school reform in 2005.¹⁷ Note that I use 4th and 5th graders for these regressions. The coefficient for the *Minas* variable has a 0.16 standard deviation increase for the mathematical regressions (0.09 standard deviation increase for Portuguese) indicating that students from Minas Gerais performed better than those from the other states. The *Post* variable is also positive with a 0.33 standard deviation increase for mathematics and 0.32 standard deviation increase for Portuguese. This gives us the same idea than the previous regressions; students get better with time i.e. students in 2011 performed better than the ones in 2007. More importantly, is the treatment variable *Minas*Post* which captures those students from Minas Gerais that have undergone the reform. This variable also shows a positive effect at a 0.21 standard deviation increase for mathematics and a 0.2 standard deviation increase for Portuguese. This further strengthens the results found in previous regressions pointing to the positive relation between starting school earlier (and having one more year of schooling) and student performance. Though this second set of regressions confirms my results, these conclusions are valid under the hypothesis that student performance would have evolved the same way throughout all the states in absence of the reform.

To conclude, my results found through the difference-in-differences estimation, point towards a positive correlation between starting school earlier and student performance. As mentioned before, I am not able to disassociate the fact that these students have started earlier and have had one more year of schooling. In any case, the results indicate a positive relation. Adding student controls, state controls

¹⁷ The states of Acre, Mato Grosso Do Sul and Roraima had less than 4% of their schools that had implemented the reform in 2005.

and using school fixed effects to better capture this effect did not change the direction of the estimations nor did it change drastically the strength of the coefficient estimates.

6 POTENTIAL PROBLEMS

Though the results found are conclusive, there are potential problems with the difference-in-differences estimator. Though the inclusion of control variables allows me to control for many aspects influencing grades, students are also unique.¹⁸ This can potentially bias my estimator since two students may be statistically "the same," but have each lived different circumstances that might explain the differences in their test scores.

Following this line of thought, certain aspects influencing student performance could not be observed. First among them is student ability. Student ability is unique to each individual and the data available does not allow me to control for this factor. The cohorts in 2011 might have been formed by generally stronger students. This could happen randomly, but could also be the result of some past public policy, for example. If this were the case, the differences in test scores would be due to this factor, and not to the reform, rendering my results upwards biased for the reform coefficients. As typically in this type of analysis, student ability is essentially the key variable that explains student performance, but the data does not allow me to have a proxy for it.

Effort is another variable in student performance that is difficult to control for. Though clearly affecting test scores it remains one of the hardest variables to measure. The data did reveal if the students did their homework, but did not reveal efforts in the classroom. Student performance might also be affected by home environment, yet another unknown in this analysis. The data has no information on student family situations or on values hinting at proactive parents, which are typically hard to measure. These omitted variables bias the estimator since there is no way of knowing whether

¹⁸ Many factors that could possibly influence a student's grades were not accounted for here such as the food the students ate in the morning, the time their parents spent revising their homework, etc.

the cohorts differed in terms of family situations.¹⁹ Though I try to measure income through computers with internet at home it is clear that better data with total family income would give a better picture on the reform's impact. Another problem is that the difference-in-differences model cannot explain a separate trend that I might have missed such as students studying more for their exams in 2011 in different grades.

Another potential problem is when I control for states. Though I suggest the hypothesis that the states evolved the same way between 2007 and 2011 (if not for the reform), it is possible that they did not. Local economical factors may have had an impact on student performance but I do not take those into account. Furthermore, though the percentages of schools that had implemented the reform in Acre, Mato Grosso Do Sul and Roraima is minimal (less than 4%), there is still an error margin here affecting my results. Since the numbers are relatively small, I believe the direction of the results is still correct in assuming that there is a positive relationship between starting school earlier and student performance.

Finally, an additional potential problem is the fact that some schools and teachers might encourage their worst students to stay at home during ministerial exams enabling the school to get a better review and rating in the region. For the same reason, teachers might also help their students during the tests.²⁰ This would mean that our estimations are upwards biased since in reality these students would bring the average test scores down.²¹

7 POLICY IMPLICATIONS

Taken at face value, findings could have some policy implications for the state of Minas Gerais, and to Brazil more generally, as my results indicate higher test scores for both mathematics and Portuguese after the reform. I associate these positive results with the fact that cohorts of students

¹⁹ This might not be the case if these omitted variables were correlated with the regressors of interest.

²⁰ This is a well-known problem that is difficult to account for. Teachers in Brazil could easily have the same reasons to cheat the test as teachers in North America, see Williams (2013).

²¹ This also depends on whether the reform made it more likely or not to have students skipping the test.

started school at a younger age. The reform seems to have been a success in terms of improving student performance. That being said, further research should be conducted in regards to other variables such as drop-out rates or long term earnings to add more information to the school starting age debate. Also, the reform affected both starting school earlier and having more schooling. It is hard for me to disentangle these two effects and the maturity issue may or may not be large enough to cancel the added schooling effect.

Also, a policy of adapting curriculum to the new school starting age could be envisioned. There are two debates here, one is school starting age and the other one is the school material students should learn depending on their school starting age. That is, research could focus on what concepts are better to be seen at a certain age. Another option is teacher training which could be considered since teachers must learn to adapt to new class ages and possibly class learning speeds. This would also be necessary if there were to be curriculum changes. Lastly, my findings seem to indicate an important relation between homework and student performance. School boards, principals, teachers and perhaps most importantly parents have to realize how crucial homework is to ensure children's academic success.

8 CONCLUSION

The 2005 Brazilian reform presented me with a unique opportunity to study the relevance of school starting age in education. Using differences-in-differences estimations combined with mathematics and Portuguese test performances I conclude that school starting age is negatively related to student performance. Once again, there are two effects being accounted for and those are starting school earlier and having one more year of schooling. That being said, these two effects combined together make for a positive correlation with student performance. The differences-in-differences estimation allowed me to control for the evolution of students through time and isolate as closely as I could the impact of starting school at the age of 6 instead of 7. Depending on the models and the

controls I use, I find different values that can be attributed to starting school earlier. In the basic model, I find a 5.8% (0.28 standard deviation increase) improvement on mathematics test scores and 3.1% improvement for Portuguese test scores (0.14 standard deviation increase) linked with starting school at an earlier age. When adding controls my findings still indicate positive correlation (still close to 5%) between starting school early and student performance. My results when using other state as controls that had not undergone the reform are in a similar direction with similar magnitudes.

Of course, this study is on one state of one country and it would be interesting to have further research investigate the case in other countries. Also, the population of Brazil might not have adapted completely to this recent change in their education system and so the same study applied with newer data could still be relevant. Other potential avenues to investigate include the relationship between school starting age and failing rates or the relationship between school starting age and school attainment. How is Brazil's future job market affected by such a reform? Is the reform relevant for college-bound graduates? Other potential benefits of the reform that should be analyzed include mothers being able to join the workforce one year earlier, children being exposed to a school environment longer might make them better law-abiding citizens, etc. In conclusion, school starting age remains an interesting debate in the literature and hopefully this study sheds some light on its relation with student performance.

Appendix A: Tables

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Table 1: Descriptive Statistics

Variable	2007 Grade 4			2011 Grade 5			Difference
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	
Port. Result	179.988	43.995	256,64	204.346	47.292	265,76	**
Mat. Result	199.781	45.763	256,64	226.177	48.566	265,76	**
Computer	0.215	0.411	219,01	0.415	0.493	257,79	**
Fail	0.28	0.449	163,14	0.230	0.421	251,51	**
Drop-out	0.065	0.247	111,85	0.057	0.232	252,78	**
Port. Homework	0.820	0.384	121,32	0.796	0.403	251,29	**
Mat. Homework	0.837	0.369	145,33	0.818	0.386	252,14	**
Male	0.490	0.5	143,47	0.506	0.5	254,93	**

Note: ** significant at the 1% level

Table 2: Descriptive Statistics

Variable	2007 Grade 8			2011 Grade 9			Difference
	Mean	Std. Dev.	N	Mean	Std. Dev.	N	
Port. Result	237.359	44.795	227,91	254.171	45.531	213,18	**
Mat. Result	252.708	45.642	227,91	264.404	46.837	213,18	**
Computer	0.232	0.422	221,81	0.503	0.5	211,24	**
Fail	0.349	0.477	217,96	0.321	0.467	209,49	**
Drop-out	0.077	0.266	217,5	0.040	0.196	209,95	**
Port. Homework	0.612	0.487	211,57	0.623	0.485	209,1	**
Mat. Homework	0.592	0.491	205,29	0.888	0.315	209,51	**
Male	0.461	0.498	224,15	0.461	0.498	209,81	

Note: ** significant at the 1% level

Table 3 : Differences in Differences Regression Results
with Mathematical Test Scores

Dep. Variable: Mathematical Results			
Model	(1)	(2)	(3)
Age_10	-52.927 (0.132)**	-52.876 (0.378)**	-50.282 (0.382)**
Post	11.696 (0.139)**	11.457 (0.275)**	5.099 (0.268)**
Age_10*Post	14.699 (0.191)**	15.555 (0.401)**	12.16 (0.418)**
Computer			6.899 (0.138)**
Fail			-25.904 (0.146)**
Drop-Out			-6.008 (0.248)**
Mat. Homework			12.465 (0.149)**
Male			7.772 (0.113)**
School Fixed-Effects	No	Yes	Yes
Mean of Dep. Var.	233.88 (52.94)	233.88 (52.94)	233.88 (52.94)
Constant	252.708 (0.096)**	252.563 (0.216)**	250.863 (0.216)**
R2	0.22	0.16	0.2
N	963,483	963,483	714,762

Note: ** significant at the 1% level

Table 4: Differences in Differences Regression Results
with Portuguese Test Scores

Dep. Variable: Portuguese Results			
Model	(1)	(2)	(3)
Age_10	-57.371 (0.128)**	-57.37 (0.351)**	-52.556 (0.324)**
Post	16.812 (0.136)**	16.571 (0.261)**	13.582 (0.249)**
Age_10*Post	7.546 (0.186)**	8.373 (0.380)**	1.673 (0.369)**
Computer			7.485 (0.131)**
Fail			-23.59 (0.136)**
Drop-out			-4.836 (0.264)**
Port. Homework			9.737 (0.132)**
Male			-10.565 (0.109)**
School Fixed-Effects	No	Yes	Yes
Mean of Dep. Var.	216.691 (53.652)	216.691 (53.652)	216.691 (53.652)
Constant	237.359 (0.094)**	234.39 (0.283)**	242.526 (0.278)**
R^2	0.28		
N	963,483	963,483	718,41

Note: ** significant at the 1% level

Table 5: Regressions With Other States As Control With
Mathematical Test Scores

Dep. Variable: Mathematical Results	
Minas	7.774 (0.195)**
Post	16.16 (0.223)**
Minas*Post	10.235 (0.250)**
Mean of Dep. Var.	215.174 (48.67)
Constant	192.008 (0.172)**
R2	0.071
N	937,875

Note:** significant at the 1% level

Table 6: Regressions With Other States As Control With
Mathematical Test Scores

Dep. Variable: Portuguese Results	
Minas	4.07 (0.186)**
Post	14.919 (0.217)**
Minas*Post	9.438 (0.242)**
Mean of Dep. Var.	194.688 (47.004)
Constant	175.918 (0.165)**
R2	0.06
N	937,835

Note:** significant at the 1% level

Appendix B: Data and Variables

All test scores variables are standardized by the Ministry of Education. The standardization is done at a national level, which is important in enabling me to analyze the evolution of one particular state (in this case Minas Gerais). Though this paper attempts to better understand the impact of school starting age, I have no control variable for student age. This is because the data did not include specific student age. Instead, I use the fact that school starting age requirement went from 7 to 6 in 2005. This is not as precise as some studies in the literature where student age is calculated by month (Fredriksson and Öckert, 2005), but I still get a big picture of school starting age impact.

Portuguese Result: Individual student Portuguese test score. (median 250, standard variation 50)

Mathematical Result: Individual student math test score. (median 250, standard variation 50)

Age_10: Binary variable indicating if student is in the lower or upper level of his school years. This variable takes the value 1 if the student is in 4th or 5th grade and 0 if the student is in 8th or 9th grade.

Post: Binary variable indicating if student is in the 2007 or 2011 cohort. This variable takes the value 0 if the student is in the 2007 cohort and 1 if the student is in the 2011 cohort.

*Age_10*Post*: Binary variable equalling to the product of *Age_10* with *Post*. This variable takes the value of 0 if student has not been affected by the reform and 1 if he has.

Computer: Binary variable indicating if student has a computer with Internet access at home.

Fail: Binary variable indicating if student has failed at least a year in his life where 0 indicates that he has not and 1 indicates that he has.

Drop-Out: Binary variable indicating if student has abandoned and restarted school before where 0 indicates if he has not and 1 indicates if he has.

Port. Homework: Binary variable representing student work ethic toward Portuguese homework where 0 indicates if the student reported he does not do the homework or does homework from time to time and 1 indicates if the student has reported he does homework almost all the time.

Mat. Homework: Binary variable representing student work ethic toward math homework where 0 indicates if the student reported he does not do the homework or does homework from time to time and 1 indicates if the student has reported he does homework almost all the time.

Male: Binary variable representing student gender where 1 indicates male and 0 indicates female.

Minas: Binary variable indicating if student is in Minas Gerais where 1 indicates that the student is in Minas Gerais and 0 indicates that the student is from either Acre, Mato Grosso Do Sul.

*Minas*Post*: Binary variable equalling to the product of *Minas* and *Post*.

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