Essays on public primary education in Brazil

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by

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Abstract

The first chapter of this thesis investigates the impacts of the school closures adopted in São Paulo/Brazil amid the 2009 H1N1 outbreak. I find evidence that a three-week shutdown led to a reduction in test scores equivalent to six weeks of schooling and was more pronounced among vulnerable students. The results indicate that a long period of school shutdowns, such as the one experienced during the Covid-19 outbreak, might lead to the loss of all the learning accumulated between 2007 and 2019 by an average fifth-grader. The second chapter explores the impacts of *Acelera*, an intervention that has been implemented in Recife/Brazil since 2010, and focus on primary education students lagging behind their peers and who are at least one year older than the adequate age for their grade. The program aims to adequate school curricula with students' level of learning in order to increase their performance, and grade promotion, and decrease dropout and age-grade distortion. I find evidence that the program increased the proficiency in Portuguese and math by 0.05 of a standard deviation and grade promotion by 15 percentage points (0.30 of a standard deviation). The heterogeneity analysis indicates that students with fewer years of age-grade distortion tend to benefit more from the intervention. The third chapter assesses the inefficiency of public primary education expenditures of the Brazilian municipalities. I estimate that local authorities efficiently use between 68% to 81% of their resources. This means that if they were able to emulate the best practices adopted by the municipalities in the efficient frontier, there would be a fiscal space of at least 87 billion BRL (18 billion USD), which is more than twice the 2022 *Bolsa Famílía* budget, the most import conditional cash transfer in the country. An amount that could be allocated in interventions to increase students' performance in a post-pandemic context where they are so much needed.

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1 Learning when schools shut down: the impact of the H1N1 outbreak on primary education students in Brazil

1.1 Introduction

School closures are one of the most drastic measures to contain the spread of infectious diseases. Existing evidence shows that school shutdowns, even for a short period of time, can have large negative effects on learning (Andrabi et al. (2020), Marcotte and Hemelt (2008), Donnelly and Patrinos (2021)). In 2009, amid the H1N1 outbreak, a few countries such as Brazil, Mexico, and the United States adopted this strategy to avoid the spread of the virus. In the state of São Paulo, the largest public school system in Brazil, more than half of the primary and secondary schools were closed between two to three weeks, affecting more than 5.5 million students (70% of the students). I leverage this natural experiment to estimate the impact of school closures on students' learning.[1]

In July of 2009, schoolchildren were in their winter break and amid an increase in the number of H1N1 cases, the Health Department of the state of São Paulo recommended the postponement of children's return to school. To estimate the impact of the school closures on students' proficiency in Portuguese and math, I rely mailing on the results of the national proficiency assessment, *Prova Brasil*, applied to fifth-grade students. The exam collects information on students' proficiency in Portuguese and math, socioeconomic indicators, as well as teachers' and principals' characteristics. I complement the analysis with additional information from the Census of Education, a dataset that contains several variables such as schools' amenities, school hours, length of the school year, and pupil-teacher ratio. The analysis is run at the school level and I compare distinct cohorts of fifth-graders between 2007, before the shutdowns, and 2009, the year the schools were closed.

The state of São Paulo has 645 municipalities. The state government, whose representative is the Governor, and the municipal governments, whose representatives are the mayors, share the responsibilities for the provision of public primary and secondary education. In each one of

[1] I focus on the state of São Paulo since the state has the largest public network in the country and where I could find, by checking local newspapers, the name of the municipalities whose local authorities opted to close the schools under their management.

these municipalities, there is at least one school managed by the state authority (state-managed school) and one school managed by the respective local authority (locally-managed school). The main roles of the state and municipal governments are to hire teachers, provide textbooks, appoint principals, finance school infrastructure, and determine the length of the school day, school breaks, as well as the beginning and the end of the school year in the schools under their responsibility.

On the one hand, for primary education in 2009, the focus of this chapter, the state government offered this level of education in 206 out of the 645 municipalities in the state of São Paulo and enforced the shutdowns in all its state-managed schools. On the other hand, the local authorities that provide primary education in 642 out of the 645 municipalities had the autonomy to decide whether or not to follow the same guideline. In the end, thirteen out of these 642 local authorities extended children's winter break in their locally-managed schools. Overall, more than three thousand primary education state and locally-managed schools were closed. The remaining 629 out of the 642 local authorities followed the calendar of their five thousand primary education locally-managed schools as previously planned, providing a group from which the closed schools can be compared.[2]

Among the factors that might have played an important role in the local authorities' decision to impose school shutdowns are population size, number of confirmed H1N1 cases per thousand inhabitants, the capacity of the health system, number of students per school and per class, and power of teacher's union (a fact that can be associated with the percentage of teachers with tenure). Indeed, six out of the thirteen municipalities in which the local authority decided to close its locally-managed schools are among the nine more populous in the state of São Paulo. On average, these municipalities registered more confirmed cases of H1N1 per 100 thousand inhabitants between April and July (10×2 cases, Figure A.2). Also, the percentage of teachers with tenure in their locally-managed schools is 20 percentage points higher (Table A.1).

To estimate the impact of the shutdowns on the locally-managed schools, I explore the policy variation between municipalities under a difference-in-differences (DiD) design. I then compare locally-managed schools of the municipalities whose local authority extended children's winter break with locally-managed schools of the municipalities whose local authority followed the

[2]The municipalities in which the local authorities decided to extend the children's winter break are presented in Figure A.1.

school calendar as previously planned. In order to test for parallel trends, the analysis is restricted to locally-managed schools that have proficiency data available since 2005.[3] This is the case for ten out of the thirteen municipalities that postponed children's return to school and for 469 municipalities that did not. The DiD sample has 795 locally-managed schools that were closed and 2,568 that remained open (Table 1.2). To account for the factors that might have influenced the mayors' decision to impose school shutdowns and that are correlated with students' performance, I include municipalities' fixed effects, and several controls that summarize students', teachers', principals', and schools' characteristics.

Under the DiD approach, one may wonder whether the influence of unobserved time-varying factors might affect differently the municipalities where the local authorities postponed children's return to school and the municipalities where the local authorities did not. If there are unobservable time-varying factors correlated with both the mayor's decision to extend the winter break and students' proficiency, the estimates will be biased. For example, the higher incidence of H1N1 cases in the municipalities that postponed the return to school could result in more students taking care of relatives leading to less time to study. Also, student and teacher absenteeism and psychological distress could have increased at a higher pace in municipalities more affected by the pandemic.

To overcome this identification threat, I leverage a within municipality variation created by the school shutdown policy that allows me to estimate the impact of the shutdowns on the state-managed schools. For the same municipality, I am able to compare its state and locally-managed schools where, therefore, children were affected by the same shocks at the municipality level. I restrict the sample to the municipalities where there is at least one state-managed school and one locally-managed school. This is the case for 112 municipalities whose local authorities did not extend the winter break (a group that I classify as $G = 1$), and for ten out of the thirteen municipalities whose local authorities postponed the children's return to schools ($G = 0$). I employ a triple difference-in-differences approach in order to account for the differences in the learning trajectories of state and locally-managed schools.

In the first DiD of the triple difference design, for schools located in $G = 1$, I compare 929 state-managed schools that were closed with 1,334 locally-managed schools that remained open to

[3]Not all the public schools are included in *Prova Brasil*, mostly due to their size as the exam is restricted to classes that have at least 20 students in the fifth grade.

estimate the effects of the school shutdowns and the proficiency gap between state and locally-managed schools. In the second DiD, for schools located in $G = 0$, I compare 868 state-managed schools with 759 locally-managed schools, all closed, to estimate the learning gap between state and locally-managed schools. Finally, the third difference is the result of the subtraction of the first DiD and the second DiD and it is the estimate of the effect of the shutdowns on the state-managed schools.

The results show that extending the winter break by two to three weeks led to a reduction in math scores of at least 0.18 of a standard deviation in locally-managed schools and 0.25 in state-managed ones, equivalent to at least six weeks of learning loss. I find evidence that the impacts were slightly stronger in schools in the bottom deciles of the math test score distribution, suggesting that the impacts were more pronounced among students lagging behind in mathematics. For Portuguese, the effects are restricted to schools managed by the state authority and reach at least 0.18 of a standard deviation, suggesting that the effects can vary by the school's level of administration.

I compliment the analysis by looking at three potential mechanisms: principals' managerial skills, teacher absenteeism, and a shorter time frame to cover school curricula in closed schools. First, for the state-managed schools, I find suggestive evidence that the higher the teachers' perception of principals' skills, the more the negative impacts of the shutdowns are offset. Second, in state-managed schools where teacher absenteeism is seen as a big issue, the learning loss is at least 60% higher compared to state-managed schools where absenteeism is not a concern. Also, the data do not indicate that state-managed schools extended the length of the school year to compensate for the period of shutdowns. For state and locally-managed schools, it is likely that the rush to cover the school curriculum made it challenging for students to keep pace with it. Finally, for locally-managed schools, the shorter length of an average school day also seems to have been a concern.

Amid the Covid-19 outbreak in 2020, almost all countries worldwide have adopted school shutdowns to contain the number of cases to rise. By the end of April 2020, more than 1.5 billion students in 190 countries were out of school (UNESCO and the World Bank). A year and a half later, more than 50% of Latin American children had not returned to school yet. In Brazil, approximately 48 million students attending primary and secondary education were

impacted by the school shutdowns.[4] Even though some schools have adopted remote learning, many children lack the required equipment, access to broadband internet, a suitable environment for studying, or the presence of an adult who can help with the new teaching routine (Rogers and Sabarwal (2020)). In the state of São Paulo, schools were closed for 56 weeks, which is at least a whole school year.

Isolating the impacts of the school shutdowns amid the Covid-19 outbreak on children's human capital accumulation is challenging because of two main reasons. Firstly, the pandemic is not over yet, and secondly, children's well-being was affected through multiple channels such as negative income shocks faced by parents, loss of relatives, and a long period of social isolation.

Although it is not the primary goal of this chapter to extrapolate the results to the Covid-19 scenario, I do so to shed some light on the potential causal impacts of a long period of school closures on learning outcomes. I acknowledge that the current pandemic outbreak is being way more detrimental to individuals' lives than the H1N1 and the period of the shutdowns is significantly longer. Thus, the attempt to proxy the impacts of the Covid-19 on children's learning using my estimates is imperfect and reliant on strong assumptions.

São Paulo was one of the first states to adopt remote learning, however, considering the low compensatory effects of the remote-learning, I estimate that the 56-week shutdown would lead to a drop in proficiency equivalent to all the learning accumulated since 2007 and 2009 by an average student of the state and locally-managed networks, respectively.[5] The magnitude of the estimates is in line with the available evidence on the impacts of school closures during the Covid-19 pandemic (Maldonado and De Witte (2020), Tomasik et al. (2021), and the World Bank forecasts.[6])

In the process of returning to schools, some of the main policies recommended to mitigate the adverse effects include: administering proficiency tests to identify the content that should

[4]Synopsis of primary and secondary education disclosed by the National Institute of Education and Research (*Instituto Nacional de Estudos e Pesquisas Educacionais* - INEP), 2019.

[5]The schools were closed on March 23, 2020 (see the state government resolution in this link: https://www.saopaulo.sp.gov.br/wp-content/uploads/2020/03/decreto-64862.pdf.) On April 22, 2020, students started remote learning. In October 2020, part of the schools reopened with limited capacity. However, the mandatory return to in-person classes only occurred in October 2021, that is, 17 months later. One year has at least 200 school days (40 weeks). Therefore, these 17 months would be equivalent to at least 56 weeks of school closures.

[6]See this post in this link: https://blogs.worldbank.org/voices/we-are-losing-generation-devastating-impacts-covid-19

be prioritized and the most vulnerable students who will need special attention; lengthening the school day; shortening planned holidays for December and January; promoting emotional support and campaigns to raise awareness about returning to school (via TV or digital media); and continuing and improving distance learning platforms to complement classroom learning. Providing emotional support for students who faced trauma is critical. There is a significant body of evidence suggesting that counseling can improve student grades, attendance, behavior, and graduation (American School Counselor Association (2015)). Awareness campaigns might also be effective in avoiding student dropouts, especially among girls and other vulnerable groups (Rogers and Sabarwal (2020)).

The contributions of the chapter are twofold. First, since most of the available evidence on the effects of school shutdowns is for developed countries (Donnelly and Patrinos (2021)), my work provides treatment effects estimates amid a recent pandemic episode (2009) in a developing country strongly hit by the Covid-19 outbreak. Second, I use my results to estimate the potential impacts of a long period of school shutdowns brought in by the current pandemic crisis on the learning outcomes of primary school children, and consequently on the challenges faced by policy-makers in the near future.

Apart from this introduction, this chapter is organized as follows: Section 1.2 presents a literature review. Section 1.3 summarizes the H1N1 outbreak. Section 1.4 introduces the data available to perform the analysis. Section 1.5 discuss the empirical strategy. Section 1.6 presents the main findings. I then conclude with a discussion and policy implications in Section 1.7.

1.2 Related Literature

The strategy to impose school shutdowns during pandemics dates back to 1916 when several cities in the United States decided to impose this policy during the polio outbreak. This strategy affects learning levels that might lead to long-lasting consequences. Younger children have their learning disrupted in a critical period of development. Literacy and numeracy instruction in early grades constitutes the foundation that future learning will take place (Rogers and Sabarwal (2020)). Furthermore, since knowledge is cumulative, if children fail to achieve the right set

of skills in elementary education, they will struggle to learn in later grades (Crouch and Gove (2011)). Meanwhile, older children may opt to drop out of school to join the labor market or even due to teenage pregnancies and early marriages.

The school shutdowns tend to widen gender gaps because of girls' increased dropout rates. As a result of being out of a protective environment, girls are more vulnerable to sexual abuse. During the Ebola outbreak, higher rates of transactional sex, and early and forced marriages were reported as families struggled to cover basic needs. Teenage pregnancy increased by 65% in Sierra Leone and girls were 16 percentage points less likely to be in school after the reopening (United Nations Development Programme (2015), Rogers and Sabarwal (2020)). Since the Covid-19 outbreak in March 2020, more than 20 thousand girls aged 10 to 14 have become mothers in Kenya, a country where 2 out of 5 teenagers are either pregnant or mothers already.[7] All these factors decrease the likelihood that affected girls will return to school.

In 1916, several cities in the USA imposed school shutdowns for up to one month as an attempt to control the spread of the Polio pandemic. Meyers and Thomasson (2017) explores the fact that the more affected cities were the ones to impose school closures. The authors then use morbidity rate as a proxy for school shutdowns. They find evidence that a 1% increase in the morbidity rate resulted in people aged 14 to 17 during the outbreak having a 6% reduction in their average educational attainment 22 years after it. The authors claim that children of legal working age might have decided to join the labor market and not return to school after the reopening.[8]

Another starting point to estimate the consequences of school shutdowns is to explore the effects of other situations that lead children to be away from school. Marcotte and Hemelt (2008) assesses the impacts of unscheduled school closings due to more severe winters in Maryland/USA. Using data from 1994 to 2005, the authors find evidence that each school day lost reduces the percentage of third-graders who perform satisfactorily in reading and math by 0.5%. In a typical winter with an average of 5 days of unscheduled closures, nearly 3% fewer students pass reading and math tests. Their results also suggest that the longer the period away from school, the more seriously disruptive is the effect on math performance. It is

[7] https://citizentv.co.ke/news/president-uhuru-on-teenage-pregnancies-there-will-be-hell-to-pay-for-chiefs-perpetrators-337610/.

[8] By that time, the legal working age was above 13 in most states of the USA.

estimated that in years with 3 to 5 days of closures, each day lost will cause 0.25% fewer students to achieve a satisfactory proficiency, while in years with 8 to 10 days, the percentage is 0.33%, and it reaches 0.5% when students lose more than 12 days.

Andrabi et al. (2020) study the effects of the 2005 earthquake in Pakistan on human capital accumulation. The authors find evidence that four years after the incident, there was a full recovery of a large number of household and adult outcomes, which is likely to be explained by the massive aid from the government. However, there was a significant shortfall in the learning levels of children aged 3 to 11 during the earthquake. Children who lived at a maximum distance of 20 km from the fault line, where schools remained closed for an average of 14 weeks, had test scores 0.4 standard deviations lower than children who lived farther from it. This result is equivalent to two years of schooling. The earthquake not only increased inequality across villages but also sharpened the differences within them, as the losses were all felt by children whose mothers had not finished primary education.

Belot and Webbink (2010) investigates the long-term effects of a 5-month school interruption caused by the 1990 teacher strike in Belgium. The results indicate that the educational attainment of the affected cohort lags behind 0.7 years, which is likely due to the increase in repetition rates. Since there was no official change in the school calendar after the strikes, students entered the next level less prepared and were probably not able to catch up with the missing content, causing higher repetition. Besides that, the probability of having a university diploma fell by 2% in the cohort affected by the strikes.

School closures will likely increase the learning gap between students from high and low socioeconomic backgrounds. Even though the actual school closures are not an extended vacation, the literature on learning loss that happens during winter breaks can also shed some light on this subject. Research has shown that students' skills and knowledge often deteriorate during the 3-month summer vacations in the USA, with low-income students facing more substantial losses (McCombs (2011)).

Alexander et al. (2007) estimates that two-thirds of the achievement gap of ninth graders from high and low socioeconomic backgrounds in Baltimore/USA could be attributed to summer learning loss in the first five years of schooling. The learning gap might help to explain the

higher dropout rates of vulnerable students, the lower percentage of them that follow a college-preparatory high school program, and that goes to college.

A meta-analysis conducted by Cooper et al. (1996) indicates that students from grades 1-9 lost the equivalent of one month of instruction during the three months of winter break in the USA. The detrimental effects are higher for math than for reading. While for math, the impacts are harmful regardless of the income levels, the decrease of reading skills is concentrated among low-income students.

Children tend to forget more math than reading as the majority of their exposure to math happens in school from teachers. On the other hand, reading skills are more affected by factors outside school as families are more likely to promote and practice literacy skills at home. Exposure to reading can vary with socioeconomic background, with low-income students falling behind the summer and high-income students making gains. Different availability of opportunities to practice reading can explain these results, as wealthier children have more access to books and are more prone to participate in summer activities that require literacy skills (McCombs (2011)).

Traumatic experiences affect the potential to learn. A context of a pandemic that involves death, loss, insecurity, social isolation, and increased exposure to domestic violence can affect children's well-being and learning. The Global Education Monitoring Report (2019) points to the disruptive effects on learning as physical; emotional, with anxiety, fear, lack of emotional control, and sadness; and cognitive, expressed via difficulty to paying attention, inability to process information, and memory problems. Besides worsening the interaction with other students, these factors might affect the student-teacher relationship.

1.3 Background: The H1N1 outbreak and school shutdowns in São Paulo

In June 2009, a new influenza outbreak, the H1N1 (also known as swine flu), was declared a pandemic by the World Health Organization (WHO).[9] From April to December 2009, Brazil confirmed 54,171 cases and 2,196 deaths from H1N1.[10] However, the number is likely to be

[9]By May 2010, 214 countries had reported cases and an estimated death toll of more than 200,000 people (The World Health Organization (2010), Dawood et al. (2012)).

[10]DATASUS, 2009. Available through: http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sinannet/cnv/influbr.def.

much higher as many people with flu symptoms do not seek help, not all the ones that look for health assistance are tested, and the under-reporting of hospitalizations and deaths are publicly known.

To avoid the spread of the disease, the Health Departments of several Brazilian states, such as São Paulo, Minas Gerais, Rio de Janeiro, Paraná, Rio Grande do Sul and Distrito Federal, recommended school shutdowns, as this policy is an important component of a community's social distancing efforts (Adda (2016)).[11] Children are less likely to adopt behavioral changes, such as washing hands and reducing physical touch, more prone to sustain person-to-person contact for prolonged times, and in some cases, more susceptible to infectious diseases, potentially acting as a vector of transmission (Klaiman et al. (2011)).[12]

In July of 2009, children were at the winter break of the school year. Amid the increase in the number of cases, at the end of that month, the Health Department of the State of São Paulo, where 8% of all national cases were registered, recommended that schools extended the winter break.[13] The Departments of Education of the state government, whose representative is the Governor, and of the municipal governments, whose representatives are the mayors, could decide whether or not to follow this guideline.

Public and private schools offer primary and secondary education in Brazil. The public system is decentralized and the 26 states, the Federal district, and the 5,570 municipalities share the responsibilities for the provision of public education.[14] Hence, the schools located in all the Brazilian municipalities can be managed either by the state government or can be under the management of the municipal government.[15] The first group of schools is state-managed, and the second group of schools is locally-managed. The main roles of the state and municipal

[11] See the list of the states in this link: https://www1.folha.uol.com.br/cotidiano/2009/08/602634-escolas-e-universidades-adiam-volta-as-aulas-devido-a-gripe-suina-veja-lista.shtml.

[12] Another countries, such as the USA and Mexico, also adopted social distancing measures to slow the spread of the disease. The guidelines included staying home when ill unless to seek medical care, avoiding large gatherings, telecommuting, and closing schools. In Mexico City, the shutdowns affected 7 million students from kindergartners to college (Lacey and McNeil Jr (2009)). In the USA, the Centers for Disease Control and Prevention (CDC) recommended school closures for 14 days if H1N1 was identified among the students. The country closed 726 primary and secondary schools, affecting 368,282 students (Klaiman et al. (2011)).

[13] Check the official statement of the state government of São Paulo in this link: https://www.saopaulo.sp.gov.br/ultimas-noticias/nota-oficial-da-secretaria-da-saude-sobre-retorno-as-aulas/.

[14] The 1988 Constitution established that the Federal Government, the 26 states and the Federal District, and the 5,570 municipalities should share the responsibilities for the provision of education. The municipal governments should give priority to early childhood and primary and lower secondary education; and the state governments to primary, lower secondary, and upper secondary education.

[15] I use the terms municipal government and local authority interchangeably.

governments are to hire teachers, provide textbooks, appoint principals, finance school infrastructure, and determine the length of the school day, school breaks, as well as the beginning and the end of the school year in the schools under their responsibility.

The state of São Paulo has 645 municipalities. In each one of these municipalities, there is at least one locally-managed school and one state-managed school offering either kindergarten and preschool, primary or secondary education. The state government decided to follow the guidelines of the Health Department and postponed for two weeks the students' return from the winter break in all the state-managed schools. In total, across all the municipalities of the state, 9,787 state-managed schools were closed, affecting more than 4 million students (Table 1.1).

The local authorities of the 645 municipalities in the state were free to decide whether to follow the same guidelines in the schools under their management. In the end, thirteen municipal governments followed the state guidance: São Paulo, the state capital, Campinas, Diadema, Embu das Artes, Indaiatuba, Mairiporã, Osasco, São Bernardo do Campo, Santo André, São Caetano do Sul, Sumaré, Ribeirão Preto and Taboão da Serra (Figure A.1). These municipalities postponed the winter break of their locally-managed schools for two to three weeks. In total, 3,170 state-managed schools were closed, affecting more than 1 million students (Table 1.1). In the remaining 632 municipalities, the calendar of the locally-managed schools did not change.

As shown in Table 1.1, on the one hand, 12,957 state and locally-managed schools were closed, which represent more than half of the public schools in the state of São Paulo, affecting more than 5.5 million students (70%).[16] On the other hand, 12,192 locally-managed schools with almost 2.5 million students remained open.

Since the state government extended the winter break of all the state-managed schools across the 645 municipalities, but only thirteen, out of 632 local authorities, decided to adopt the same measure in the schools under their management, it is important to investigate what factors influenced their mayor's decision. Among the factors that might have played an important role are: population size, number of confirmed H1N1 cases per thousand inhabitants, the capacity of the health system, number of students per school and per class, and power of teacher's union

[16] Census of Education/INEP, 2009.

(a fact that can be associated with the percentage of teachers with tenure).

Indeed, six out of the thirteen municipalities in which the municipal government decided to close the locally-managed schools are among the nine more populous in the state of São Paulo. All the thirteen ones are between one-fifth more populous. On average, these municipalities registered more confirmed cases of H1N1 per 100 thousand inhabitants between April and July (10×2 cases, Figure A.2). Also, the percentage of teachers with tenure in their locally-managed schools is 20 percentage points higher (Table A.1).

Table 1.1: State and locally-managed schools in São Paulo (2009)

	Students					Schools				
	Total	Pre-K	Primary Education	Lower Secondary	Upper Secondary	Total	Pre-K	Primary Education	Lower Secondary	Upper Secondary
Schools shutdown, extension of the winter-break										
State-managed schools located in all the 645 municipalities in the state of São Paulo	4,338,887	1,193	852,116	1,870,373	1,615,205	9,787	39	2,144	3,833	3,771
Locally-managed schools located in 13 out of the 645 municipalities in the state of São Paulo	1,202,386	454,499	454,703	281,392	11,792	3,170	1,579	972	596	23
Total	5,541,273	455,692	1,306,819	2,151,765	1,626,997	12,957	1,618	3,116	4,429	3,794
No school shutdown, no extension of the winter break										
Locally-managed located in 632 out of the 645 municipalities sin the state of São Paulo	2,458,858	727,745	1,380,053	326,645	24,415	12,192	6,204	4,956	947	85
	% of students affected by the shutdowns					**% of schools affected by the shutdowns**				
	69.3%					51.5%				

Notes: Pre-k: Kindergarden and pre-school. Primary Education: first to fifth grades. Lower secondary: sixth to ninth grades. Upper secondary education: tenth to twelfth grades (high-school). The locally-managed schools: schools managed by the local authorities of the 645 municipalities in São Paulo. The state-managed schools: schools managed by the state government of São Paulo.
Source: Census of Education, 2009.

It is also important to understand the main differences between the locally-managed schools of the municipalities where the local authority extended the winter break and the locally-managed schools of the municipalities where the local authority followed the school calendar as previously planned. I then run a regression of a dummy indicating whether the school s in municipality m was closed in 2009 on 2007 data of GDP per capita of the municipality, municipality population size, number of confirmed cases of H1N1 per 100 thousand inhabitants, and students', teachers' and principals' characteristics. I find that the main differences between them are that the locally-managed schools of the municipalities where the local authority extended the winter break had shorter school days (4.8 hours in affected schools $\times$ 5 hours in the unaffected ones), higher percentage of principal that see teachers' absenteeism as a big issue (26.7% $\times$ 7.7%), as well as students' absenteeism (8.7% $\times$ 4.2%), higher percentage of teachers with tenure (64.7% versus 49%), and lower levels of principals' managerial skills according to teachers' perspective (0.72 $\times$ 0.77) (Table A.2).[17]

1.4 Data

To assess the impact of 2009 school shutdowns on students' proficiency in Portuguese and math, I use data from the Census of Education, the Brazilian Institute of Geography and Statistics (IBGE), and from *Prova Brasil*, which is the national proficiency exam to assess students' learning levels.[18]

The Brazilian legislation for primary and secondary education determines a school year with a minimum of 200 days and 800 hours of instruction time. The state-managed schools are

[17] All the descriptive statistics presented are relative to 2007 and based on the Brazilian Ministry of Education questionnaires that are filled out by students, teachers, and principals. Tables upon request. The principal managerial skills is an index ranging from 0 to 1. It is calculated based on teachers' answers of how frequently they believe that the principal pays attention to students' learning, administrative norms, and school maintenance; motivates the teachers and encourage new ideas, and take into consideration teachers' inputs; and whether teachers trust the principal and can participate of the decisions related to their work. All these variables have four possible answers: never (value 0), sometimes (0.33), often (0.66), and always (1). The principal managerial skills index at the teacher level is an average of these answers, and the index at the school level is an average of teachers' answers. The student motivation is an index ranging from 0 to 1. It is calculated based on the teachers' answers on whether students' learning deficit is caused by low student motivation or bad behavior in class. These variables have two possible answers: yes (0) and no (1). The variable students' absenteeism is also part of the index and has three possible answers: a moderate/big issue (0), a small issue (0.5), and not a problem (1). The student motivation index is an average of these answers. Teacher motivation is an index ranging from 0 to 1. It is calculated based on students' answers of how frequently the teacher corrects their Portuguese and math homework. The variable has three possible answers: always (1), sometimes (0.5), and never (0). The teacher motivation at the school level is an average of students' answers.

[18] IBGE stands for *Instituto Brasileiro de Geografia e Estatística*. IBGE has information on GDP per capita and the population at the municipality level.

monitored by the State Department of Education, under the state government administration, and locally-managed schools are monitored by the Municipal Department of Education, under the municipal government administration. The Departments of Education are in charge of educational policies implemented at the school level, hiring school staff, and elaborating the school calendar, among other things. Usually, the school year goes from February to November, summer break occurs in December and January, and winter breaks cover two weeks in July.

Since 1995, all private and public schools offering primary and secondary education participate in the annual Census of Education. The Census is implemented by the National Institute of Educational Studies and Research (INEP), a research agency under the Brazilian Ministry of Education.[19] The Census collects information on (i) school facilities, such as libraries, sports courts, and science and computer labs; (ii) school infrastructure such as filtered water, electricity, and internet access; (iii) social services, for example, school transportation and provision of meals; (iv) students, such as gender, color of the skin, age, physical disabilities or mental illness, grade level, instruction time per day, class-size, subjects they are enrolled in, grade promotion, repetition and dropout rates; and (v) teachers, such as educational attainment, age, physical disabilities, subjects taught, and classes they are in charge of.

Every two years, the INEP applies a national exam, *Prova Brasil*, to assess students' proficiency in Portuguese and math. Since 2005, the test is applied to fifth and ninth-graders of all public schools.[20] *Prova Brasil* is one of the proficiency tests within the scope of the Education Assessment System (SAEB).[21] Students take the test at the end of the school year (between October and November). In 2007, children took the test between November 5 and 20; and in 2009 between October 19 and 31 (approximately, two months after the school shutdowns).

For fifth-graders, proficiency in Portuguese has a scale ranging from 0 to 325, and math has a scale ranging from 0 to 350 (SAEB scale). I standardized the students' proficiency in Portuguese and math in order that both dependent variables assume values from -1 to 1. Hence, the treatment effect could be measured in terms of standard deviations (SD), preventing the analysis from being scale-sensitive and allowing the comparability with other studies. The students'

[19] INEP stands for *Instituto Nacional de Estudos e Pesquisas Educacionais*.

[20] Schools with at least 20 students enrolled in fifth or ninth grade. Proficiency tests are also applied to students in the last grade of high school.

[21] SAEB stands for *Sistema de Avaliação da Educação Básica*.

proficiency can be classified as insufficient, basic, or advanced.

In addition to answer Portuguese and math questions, students filled out a socioeconomic questionnaire with information on their household infrastructure; parents' educational attainment; incentive from the family to pursue an education; time watching TV, on the internet, reading books, and doing homework; if they already dropped out or repeated a grade; and if they did kindergarten.

Data from Census of Education and *Prova Brasil* are used to calculate the National Education Development Index (IDEB), the most important educational indicator in Brazil, that monitors students' grade promotion and learning levels.[22] State and municipal governments use this indicator to monitor the improvement in the quality of public education in Brazil and to compare the schools' performance within and between municipalities. In 2020, the IDEB gained additional relevance, as the Brazilian Congress approved that part of the National Fund for Education Development (FUNDEB), the most important source of education resources in the country, will be redistributed to the municipalities according to their IDEB score.[23]

Since *Prova Brasil* is applied every two years, I use data from 2009, the year the schools were closed, and 2007, the pre-intervention year. The focus of the analysis is the fifth grade as this is the primary education grade for which the proficiency exam is applied.[24] The dependent variables of the study are then the standardized fifth-grade proficiency in Portuguese and math, and the independent variables are students and school characteristics from *Prova Brasil* and Census of Education. The analysis is run at the school level and I compare distinct cohorts of fifth-grade students.

[22]IDEB stands for *Índice de Desenvolvimento da Educação Básica*. To compute the index, the students' Portuguese and math performance is transformed into a standardized proficiency ranging from 0 to 10. The index is then multiplied by the students' grade promotion rate (in a scale from 0 to 1) to obtain the IDEB at school, municipal, state, and country levels. For example, for primary education, the index is the product of the standardized performance of fifth-graders and the average grade promotion from first to fifth grades.

[23]FUNDEB stands for *Fundo Nacional de Desenvolvimento da Educação Básica*.

[24]I did not estimate the effects of the school closures on ninth-graders because only five out of the thirteen municipalities had proficiency scores available for the ninth grade in 2007. Therefore, the number of clusters would be too small.

1.5 Empirical Strategy

To identify the treatment effects of the 2009 school closures due to the H1N1 outbreak on students' proficiency with fifth-graders in Portuguese and math, I explore the policy variation between and within the municipalities of the state of São Paulo.

In the year of the shutdowns, on the one hand, 206 out of the 645 municipalities in the state of São Paulo had state-managed schools offering primary education, and the state government enforced the extension of children's winter break across all its schools. On the other hand, 642 out of the 645 municipalities had locally-managed schools offering primary education.[25] In thirteen out of these 642 municipalities, the respective local authority adopted the same measure for their locally-managed schools. These state and locally-managed schools are the *treatment group*. In the locally-managed schools of the remaining 629 municipalities, the local authorities did not extend the winter break, providing a group from which the closed schools can be compared, the *comparison group*.

First, to estimate the impact of the shutdowns on the locally-managed schools, I explore the policy variation between municipalities under a difference-in-differences design. I then compare locally-managed schools of the municipalities whose local authority extended children's winter break with locally-managed schools of the municipalities whose local authority followed the school calendar as previously planned. In these schools, students' proficiency is available since 2005.[26] However, over the years, the test does not include all the primary education schools, mostly due to their size.[27] In 2005, 2,580 locally-managed schools have students' proficiency available for the fifth grade. In order to test for parallel trends, I restrict the DiD to municipalities whose locally-managed schools have proficiency data available since 2005. This is the case for ten out of the thirteen municipalities whose local authority extended the winter break and for 469 out of the 629 municipalities whose local authority followed the school calendar as previously planned. Overall, the sample has 795 locally-managed schools that were closed and 2,568 that remained open (Table 1.2).

Second, to estimate the impact of the shutdowns on the state-managed schools, I explore the

[25] Census of Education, 2009.

[26] Proficiency data for the state-managed schools are available starting in 2007.

[27] As described in Section 1.4, schools in which the classes have at least 20 students in the fifth grade are the ones that participate in *Prova Brasil*.

policy variation within municipalities. For the same municipality, I am able to compare its state and locally-managed schools where, therefore, children were affected by the same shocks at the municipality level. I restrict the sample to municipalities where there is at least one state and one locally-managed school offering primary education. This is the case of 112 municipalities where the local authority did not extend the winter break of their locally-managed schools (a group that I classify as $G = 1$), and for ten out of the thirteen municipalities where the local authority postponed the children's return to locally-managed schools ($G = 0$). In the first DiD, for schools located in $G = 1$, I compare 929 state-managed schools that were closed with 1,334 locally-managed schools that remained open. In the second DiD, for schools located in $G = 0$, I compare 868 state-managed schools with 759 locally-managed schools, all closed, in order to take into account the differences in the proficiency trajectory of state and locally-managed schools (Table 1.2). Finally, the third difference is result of the subtraction of the first DiD and the second DiD.

Table 1.2: Sample of the study, São Paulo

(A) Difference-in-differences

	13 municipalities where the local authorities extended the winter break (G = 0)		*Other municipalities where the local authorities did not extend the winter break (G = 1)*	
	All Locally-managed	Included DiD Locally-managed	All Locally-managed	Included DiD Locally-managed
Municipalities	13	10	629	469
Schools	972	795	4,956	2,568
Students	126,562	118,804	301,743	239,778

(B) Triple difference-in-differences

	13 municipalities where the local authorities extended the winter break (G = 0)				*Other municipalities where the local authorities did not extend the winter break (G = 1)*			
	All		Included triple DiD		All		Included triple DiD	
	State-managed	Locally-managed	State-managed	Locally-managed	State-managed	Locally-managed	State-managed	Locally-managed
Municipalities	10	13	10	10	196	629	112	112
Schools	900	972	868	759	1,244	4,956	929	1,334
Students	144,766	126,879	144,655	110,606	108,750	301,743	99,172	139,017

Notes: I only keep in the DiD sample, locally-managed schools with proficiency data available since 2005, in order to test for parallel trends. For the triple DiD, I only keep municipalities where there is at least one state and one locally-managed school. Students enrolled in fifth grade. Source: Census of Education, 2009.

1.5.1 DiD on the sample of locally-managed schools

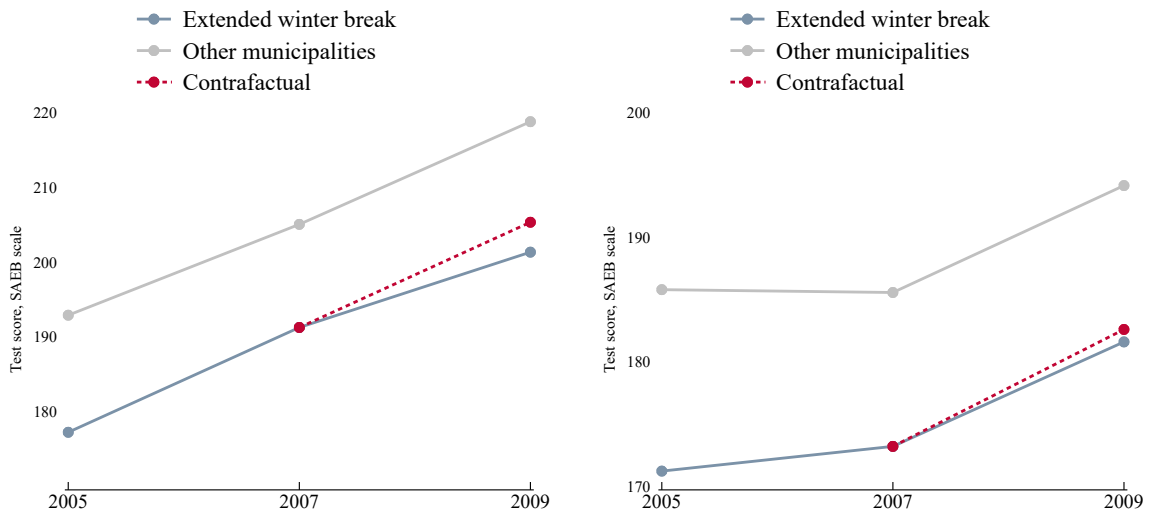
I use a difference-in-differences (DiD) approach to estimate the impacts of the school shutdowns on the locally-managed schools in São Paulo. I compare the locally-managed schools of the municipalities where the local authorities extended the winter break with the locally-managed schools of the remaining municipalities where the municipal government followed the school calendar as previously planned.

$$y_{smt} = \alpha_0 + \alpha_1 T_{sm} + \alpha_2 H1N1 + \gamma_{DD} T_{sm} \times H1N1 + \alpha_3 X'_{smt} + \delta_m + \upsilon_{smt} \tag{1.1}$$

in which y_{smt} is the proficiency of fifth graders in school s, in municipality m, in year t; T_{sm} is a dummy that equals 1 if school s is in a municipality m that extended the winter break in 2009 and 0, otherwise; $H1N1$ is a dummy that equals 1 in 2009 and 0 in 2007; X'_{smt} is a vector of control variables of students', teachers', principals', and schools' characteristics; and δ_m are municipalities fixed effects. The parameter of interest, γ_{DD}, is the average treatment effect on the treated (ATT), that is, the average effect of school closures on student learning. As schools in the same municipality may be similar, the standard error is clustered at the municipality level. As shown in Table 1.2, the number of municipalities in the treatment group (10) is significantly smaller than in the comparison group (469), therefore, the confidence interval is estimated using *wild-bootstrap* with 1,000 replications (Roodman et al. (2019)). All the regressions are weighted by the fifth-grade enrollment at the school level.

Intuitively, the effect of the winter break extension is estimated by comparing the evolution of the average test score gap between the treatment and comparison groups in 2007 (before the pandemic) and 2009 (after the pandemic). To claim causal effects of the school closures on test scores, the comparison group is expected to emulate what would have happened with the student learning in the treatment group in the absence of the school shutdowns. As shown in Figure 1.1, I find suggestive evidence that the learning outcomes in both groups were following the same trend before the H1N1 outbreak.

Figure 1.1: Performance in locally-managed schools, fifth-grade (2005-2009)



(a) Math

(b) Portuguese

Note: Data from *Prova Brasil*/INEP, Brazilian Ministry of Education. For fifth-graders, the proficiency scale (SAEB scale) ranges from 0 to 350 in Portuguese, and from 125 to 350 in Math. The proficiency for treatment and comparison groups is the average of the proficiency scores of a sample of locally-managed schools in the state of Sao Paulo, the ones that have performance of fifth-graders available since 2005. These schools are located in 10 municipalities of the treatment group and 469 in the comparison group (Table 1.2). The confrafactual was calculated assuming that the average score of the treatment group would increase at the same pace as of the comparison group in the absence of the school closures. Because the first year of *Prova Brasil* assessment was 2005, I am unable to test for parallel trends using a longer time frame. Figure A.3 shows the time-trend for grade promotion, repetition and dropout rates.

Aiming to increase precision and account for potential time-variant confounders, I include a vector of covariates at the school level, as these variables might be correlated with both the decision of the municipality to close and its students' performance in the standardized tests. I use a Lasso (*Least Absolute Shrinkage and Selection Operator*) regression to select the vector of covariates, X'_{smt}, that best predicts the variation in the proficiency score (Ahrens et al. (2019)).

The model selected the following covariates: dummy variables indicating if the school has a science and computer lab, sports court, library, and access to the internet; instruction hours per day; the number of students per class; GDP per capita of the municipality where the school is located; and socioeconomic characteristics of fifth graders. The vector of socioeconomic variables includes the percentage of mothers with a high school diploma; the percentage of students that already repeated or dropped out of school; the percentage of white students; the percentage of female students; the percentage of students that work for pay; the percentage of students that previously studied in a private school; the percentage of students who have a computer at home; the percentage of students whose parents incentive them to study, to do the homework,

to read, to not miss classes, and that talk about what happens in the school.[28]

Overall, the working sample for the difference-in-differences analysis consists of 795 schools with 118,804 fifth-grade students in the treatment group and 2,568 schools with 239,778 students in the comparison group (Table 1.2).

1.5.2 Triple DiD on the sample of state and locally-managed schools

In the DiD approach, one may wonder whether the influence of unobserved time-varying factors might affect differently the municipalities where local authorities extended the winter break and the municipalities where the local authorities followed the school calendar as previously planned. If there are unobservable time-varying factors correlated with both the mayor's decision to extend the winter break and students' proficiency, the estimates based on equation 1.1 will be biased. For example, the higher incidence of H1N1 cases in the municipalities that postponed the return to school could result in more students taking care of relatives leading to less time to study. Also, student and teacher absenteeism and psychological distress could have increased at a higher pace in municipalities more affected by the pandemic.

To overcome this identification threat, I leverage a within municipality variation created by the school shutdown policy. To do so, I consider the municipalities with at least one state and one locally-managed school and split them into two groups. Let $G = 1$ denote the 112 municipalities in which 929 state-managed schools were closed and 1,334 locally-managed schools remained open (*comparison group*). Let $(G = 0)$ denote the ten municipalities where both 868 state and 759 locally-managed schools were closed (Table 1.2). I assume that idiosyncratic shocks at the municipal level affected students from both municipal and state schools similarly.

Due to the differences in the learning trajectories, a simple comparison of state and locally-managed schools in $G = 1$ would likely lead to biased estimates of the impacts of the school shutdowns (Table A.11). On the one hand, between 2005 and 2007, locally-managed schools experienced a higher increase in average proficiency compared to state schools (Figure A.4). On the other hand, between 2007 and 2009, even with the shutdowns, there was a higher increase

[28] Tables A.3, A.4, A.5, A.6, A.7, A.8, A.9 present the descriptive statistics for selected covariates. The code is available at GitHub Folder: https://github.com/worldbank/h1n1-school-closures-sp-2009.

in the students' proficiency in the state-managed schools, which could suggest that the state government put forward some interventions intended to increase students' learning. In 2008, for example, the state government implemented a program aimed to increase managerial practices of schools in the bottom 5% of proficiency distribution. Despite the relatively small number of state-managed schools included in this intervention (621 out of 5,977), they were excluded from the evaluation sample to mitigate the risk of bias.[29]

To take into account that state and locally-managed schools have distinct learning trajectories, I compare state and locally-managed schools in $G = 1$ and $G = 0$ under a triple difference-in-differences design. The model accounts for three sources of variations. The first variation (Δ_1) consists of an estimate of the effects of the school shutdowns and the proficiency gap between state and locally-managed schools. It comes from the differences in learning outcomes across the state, closed, and locally-managed schools, opened, in $G = 1$, between 2007 (before the shutdowns) and 2009 (after the shutdowns). The second variation (Δ_2) consists of an estimate of the learning gap between state and locally-managed schools. It comes from the differences in learning across the state and locally-managed schools, both closed, between the same period in $G = 0$. Therefore, the third source of variation ($\Delta_1 - \Delta_2$) captures the effect of the shutdowns in the state-managed schools (Muralidharan and Prakash (2017)). With this strategy, I do not reject the null hypothesis of parallel trends before the school shutdowns (Table A.11).

To estimate the ATT, I use the following regression equation:

$$\begin{aligned} y_{smt} =& \alpha_0 + \alpha_1 E_{sm} + \alpha_2 G + \alpha_3 H1N1 + \alpha_4 E_{sm} \times G + \alpha_5 E_{sm} \times H1N1 \\ &+ \alpha_6 G \times H1N1 + \gamma_{DDD} E_{sm} \times G \times H1N1 + \alpha_7 X_{smt} + \delta_m + \upsilon_{smt} \end{aligned} \tag{1.2}$$

in which E_{sm} is equal to 1 if school s in municipality m is state-managed and 0, otherwise. $X'_{smt}$is a vector of control variables of students', teachers', principals', and schools' characteristics that were selected using a Lasso regression. It includes a series of variables that might be associated with how the schools reacted to the shutdowns, for example, length of the school day, managerial skills of principals according to teacher perspective, and teacher and student absenteeism. The parameter of interest, γ_{DDD}, is the average treatment effect on the treated (ATT), that is, the

[29]The focus of the managerial practices intervention was primary and lower secondary state-managed schools (Table 1.2). In 2009, the state government had 5,977 state-managed schools offering first to ninth grade.

average effect of school closures on student learning in state-managed schools. The standard error is clustered at the municipality level. All the regressions were weighted by the fifth-grade enrollment at the school level.

X'_{smt} To summarize:

- $G = 1$ are the 112 municipalities in which the municipal authority did not extend the winter break, and where there is at least one state and one locally-managed school offering first to fifth grade. These municipalities have 929 state-managed schools with 99,172 students; and 1,334 locally-managed schools with 139,017 students.
  - locally-managed schools opened.
  - state-managed schools closed.
  - 1^{st} difference-in-differences:

$$\Delta_1 = (Y^1_{E,G=1} - Y^0_{E,G=1}) - (Y^1_{M,G=1} - Y^0_{M,G=1}) = \gamma_{DDD} + \alpha_5 \tag{1.3}$$

  - in which $Y^1_{E,G=1}$ and $Y^0_{E,G=1}$ are the proficiency of state-managed schools in $G = 1$ in $D = 1$ (2009) and $D = 0$ (2007), respectively; and $Y^1_{M,G=1}$ and $Y^0_{M,G=1}$ are the proficiency of locally-managed schools in $G = 1$ in $D = 1$ and $D = 0$, respectively.

- $G = 0$ are the 10 municipalities in which the municipal authority extended the winter break, and where there is at least one state and one-locally-managed school. These municipalities have 868 state-managed schools with 144,655 students; and 759 locally-managed schools with 110,606 students.
  - locally-managed schools closed.
  - state-managed schools closed.
  - 2^{nd} difference-in-differences:

$$\Delta_2 = (Y^1_{E,G=0} - Y^0_{E,G=0}) - (Y^1_{M,G=0} - Y^0_{M,G=0}) = \alpha_5 \tag{1.4}$$

  - in which $Y^1_{E,G=0}$ and $Y^0_{E,G=0}$ are the proficiency of state-managed schools in $G = 0$ in $D = 1$ (2009) and $D = 0$ (2007), respectively; and $Y^1_{M,G=0}$ and $Y^0_{M,G=0}$ are the proficiency of locally-managed schools in $G = 0$ in $D = 1$ and $D = 0$, respectively.

- Therefore, the Triple Difference-in-differences is given by: Δ_1 - Δ_2 = γ_{DDD}

The empirical strategy faces a few caveats that are worth mentioning. First, since *Prova Brasil* started in 2005, I am unable to use data before 2005 to assess the plausibility of the parallel trends assumption for a more extended pre-intervention period. In this case, the triple difference design helps me deal with different time trends across municipalities by exploiting within municipality variation across school networks over time. Second, I do not have a panel of students. Instead, I compare distinct cohorts of fifth graders over time and run the analysis at the school level. These limitations prevent me from carrying out heterogeneity analysis to assess, for instance, whether impacts on boys and girls differ, and which subgroup of students were most badly hit by the school shutdowns.

1.6 Results

I find evidence that the school shutdowns during the H1N1 outbreak had a significant impact on students' learning, especially in math performance. The baseline estimates point to a decrease in Math scores equivalent to -0.21 and -0.28 of a standard deviation in locally and state-managed schools, respectively (Columns 1 and 4 of Table 1.3). The decrease in Portuguese scores is equivalent to -0.22 of a standard deviation and is restricted to the state-managed network.

Table 1.3: Impact of school shutdowns on students' learning, fifth-grade

	Math								Portuguese							
Estimated decrease in Math and Portuguese Proficiency, SAEB scale																
	DiD	DiD	DiD	Triple D	Triple D	Triple D	Triple D	Triple D	DiD	DiD	DiD	Triple D	Triple D	Triple D	Triple D	Triple D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
H1N1	-3.28**	-3.33**	-2.82**	-4.48***	-4.40***	-4.21***	-4.17***	-4.09***	-0.53	-0.56	-0.34	-3.47***	-3.39***	-3.40***	-4.17***	-2.73**
	(0.03)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.52)	(0.54)	(0.72)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
	[-5.5,-1.0]	[-5.6,-1.0]	[-5.1,-0.5]	[-6.2,-2.8]	[-6.2,-2.6]	[-6.0,-2.4]	[-6.1,-2.3]	[-6.5,-1.7]	[-2.2,1.1]	[-2.3,1.2]	[-2.2,1.5]	[-4.9,-2.0]	[-4.9,-1.9]	[-4.9,-1.9]	[-6.1,-2.3]	[-4.8,-0.6]
N. schools	3808	3808	3808	5032	5032	5032	5032	5032	3808	3808	3808	5032	5032	5032	5032	5032
R2	0.803	0.803	0.803	0.812	0.812	0.812	0.812	0.732	0.814	0.814	0.814	0.818	0.818	0.818	0.812	0.641
Proficiency - Treatment Group before the school shutdowns (2007)																
Mean	193.36	193.36	193.36	195.28	195.28	195.28	195.28	195.28	175.4	175.4	175.4	177.83	177.83	177.83	195.28	177.83
Sd	15.48	15.48	15.48	16.09	16.09	16.09	16.09	16.09	15.44	15.44	15.44	15.44	15.44	15.44	16.09	15.44
ATT est (in sd)	-0.21	-0.21	-0.18	-0.28	-0.27	-0.26	-0.26	-0.25	-0.03	-0.04	-0.02	-0.22	-0.22	-0.22	-0.26	-0.18
Estimated increase in the percentage of students below the basic level of learning in Math and Portuguese, in %																
	DiD	DiD	DiD	Triple D	Triple D	Triple D	Triple D	Triple D	DiD	DiD	DiD	Triple D	Triple D	Triple D	Triple D	Triple D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
H1N1	2.66**	2.71***	2.31***	4.91***	4.89***	4.76***	4.75***	5.04***	0.98	1.00	0.77	3.32***	3.28***	3.22***	3.20***	3.08***
	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.26)	(0.27)	(0.40)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
percentage of students below the basic level of proficiency - Treatment Group before the school shutdowns (2007)																
Mean	57.5	57.5	57.5	56.38	56.38	56.38	56.38	56.38	70.74	70.74	70.74	69.67	69.67	69.67	69.67	69.67
Increase, in %	4.6	4.7	4.0	8.7	8.7	8.4	8.4	8.9	1.4	1.4	1.1	4.8	4.7	4.6	4.6	4.4
(A) Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(B) Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(C) % teachers in both networks	No	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes
(D) % teachers management	No	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes
(E) School FE	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	Yes

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10% critical level. p-value in parenthesis. 95% CI in brackets. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. The rows (A), (B), (C), (D), and (E) indicate the controls included in the regression. (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented.

The magnitude of the estimates is higher than the available evidence on the impacts of school shutdowns on primary students' learning recent pandemic outbreak. Amid Covid-19 pandemic, Maldonado and De Witte (2020) find that the 9-week school closure in Belgium reduced students' math and Dutch performance by 0.19 and 0.29 of a standard deviation, respectively. Also during Covid-19, Tomasik et al. (2021) show that the 9-week shutdown in Switzerland decreased math and reading performance by 0.20 of a standard deviation.

During the Covid-19 outbreak, school shutdowns in Belgium and Switzerland were three times longer than what was experienced in Brazil during the H1N1. However, the magnitude of the effects is similar, which might be associated with the significant contrast between the students' learning levels in Brazil and OECD countries. The 2018 Programme for International Student Assessment reveals that, at the age of 15, students from Belgium and Switzerland have reading performance almost 20% higher than students in Brazil. In math, their performance is more than 30% higher. Therefore, my higher estimates for the impact of school closures might be partially explained by the reasonable assumption that students with lower baseline levels of learning would face more severe consequences. Students in Brazil have fewer resources to cope with the shutdowns, such as computers and access to the internet, especially considering that the H1N1 occurred in 2009, more than 10 years before the Covid-19, when access to broadband internet and electronics was more expensive. Also, children in Brazil have parents with lower educational attainment to incentive them to continue studying their textbooks while schools were closed.

The stronger negative effects on math are in agreement with other estimates of school shutdowns on learning outcomes (Kuhfeld et al. (2020), Thum and Hauser (2015), Baker (2013), and Cooper et al. (1996)). The available evidence suggests that out-of-school enrichment activities during school breaks tend not to focus on math, which is associated with both math anxiety and new instructional methods that differ from what parents themselves learned. In this context, instead of math, families tend to focus more on the promotion of literacy skills at home, by the reading of books, for example (McCombs (2011), Murnane (1975), Bryk and Raudenbush (1989), Allinder et al. (1992), Harris and Sass (2009)). Therefore, these would help explain why math skills depreciate faster than reading ones, why school shutdowns have larger effects on mathematics than on reading and inform policies aimed at mitigating learning losses caused by school closures.

To get a better sense of the magnitude of the treatment effects, I convert the estimates into expected years of schooling. To do so, I use as a benchmark the ideal learning gain between the fifth and ninth grades in the Brazilian school system. An average student who does not repeat a grade should experience an annual increase in proficiency of 20 points in the national standardized exam, in a learning scale that ranges from 0 to 325 for Portuguese and 0 to 350 for math (Alves et al. (2016)). Therefore, the estimated drop in math performance of -3.3 and -4.5 points corresponds to almost seven and nine weeks of learning loss in locally and state-managed schools, respectively.[30]

Given the relatively large effects of the winter break extension on learning loss, I test whether the estimated drop in test scores increased the percentage of students below the basic learning level according to the SAEB scale (Table 1.3). The baseline estimates point to an increase in the percentage of students below the basic level in math proficiency of 2.7 and 4.9 percentage points in locally and state-managed schools, respectively (a rise of 4.6% and 8.7%, compared to baseline levels). For Portuguese, the point estimate is 3.3 percentage points in state-managed schools (a rise of 4.8%, compared to baseline levels).

The relatively small increase in the proportion of students below the basic learning level suggests that the adverse impacts of the school closures were disproportionately higher among those who already lagged behind even before the pandemic. In fact, in 2007, almost 60% and 70% of the students in affected schools did not achieve basic levels of learning in math and Portuguese, respectively.[31] If the more detrimental effects are concentrated on this group of students, school shutdowns likely widened inequalities between low and high-performers.

To further investigate whether the impacts of the school shutdowns were stronger at the lower tail of the learning distribution, I estimate quantile treatment effects using the Athey and Imbens (2006) changes-in-changes (CiC) estimator.[32] For the state and locally-managed networks, the impact of the shutdowns is not statistically significant in the top 10% and 20% of schools, respectively (Figure 1.2). The absence of effects in the top of the test score distribution suggests

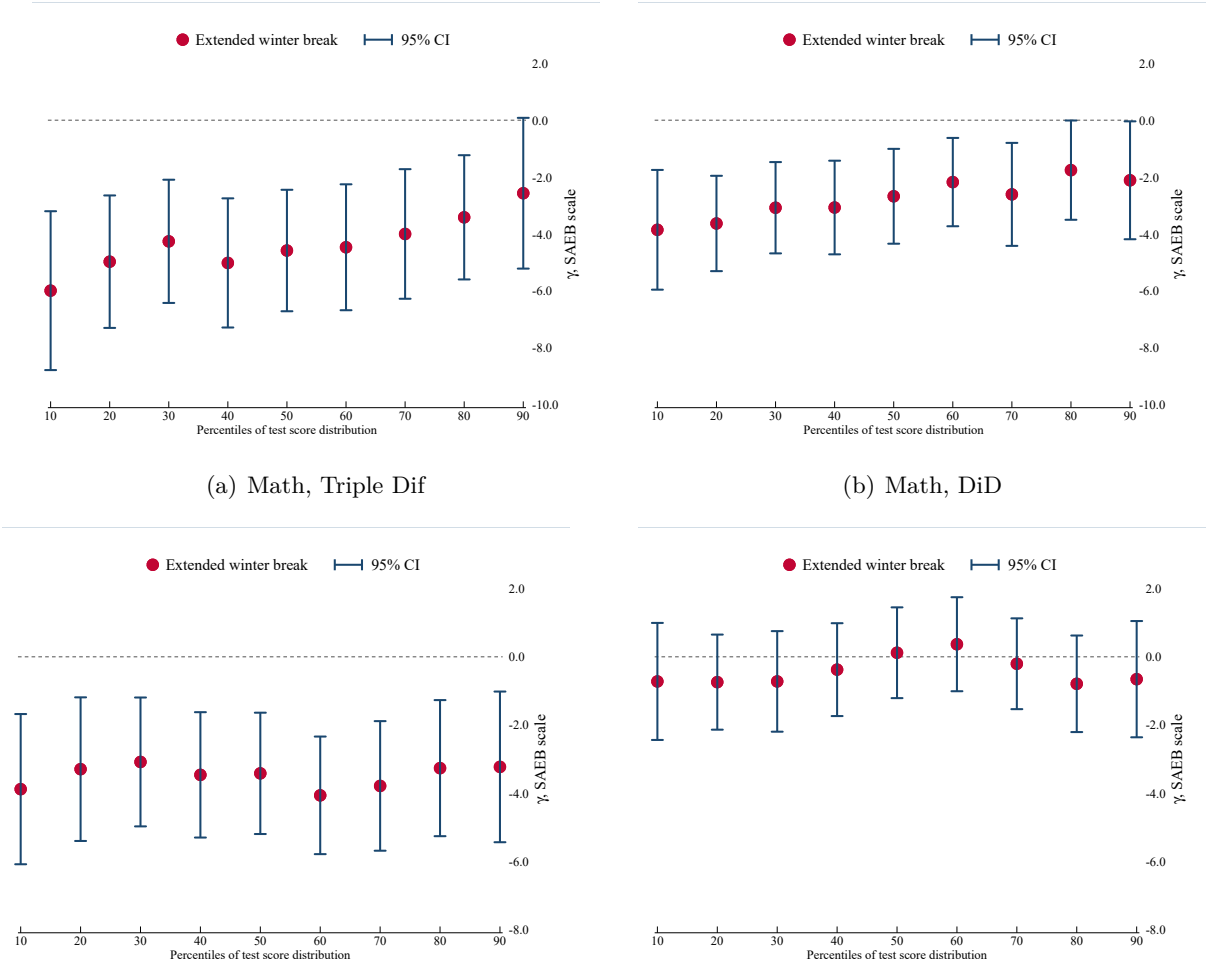
[30] 200 school days $\times$ 3.3/20 = 33 days, or 6.6 weeks (considering five school days a week). 200 school days $\times$ 4.5/20 = 45 days, or 9 weeks (considering five school days a week).

[31] Average of students with insufficient performance in 2007. The average considers all state and locally-managed schools affected by the shutdowns.

[32] I used the command *cic* in Stata to perform the estimation. This command allows the estimation of the confidence intervals with bootstrapped standard errors. However, it does not perform the *Wild Bootstrap* as defined by Roodman et al. (2019) that accounts for a small number of clusters.

that the impacts might have been stronger among math low-performers.

Figure 1.2: Impact of school shutdowns by percentiles, fifth-grade



(a) Math, Triple Dif

(b) Math, DiD

(c) Portuguese, Triple Dif

(d) Portuguese, DiD

Note: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. 95% Confidence Interval. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The figures (a) and (c) show the estimates for equation 1.2. The figures (b) and (d) show the estimates for equation 1.1. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. The controls are: municipal fixed effects, students', teachers', schools' and principals' characteristics, the percentage of teachers that work in a state and a locally-managed school at the same time, and the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. The triple difference specifications also include schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented. I perform the estimates using the stata command *cic* (changes in changes) proposed by Athey and Imbens (2006).

The more detrimental effects in the state-managed network might indicate that locally-managed schools could better respond to the students' needs when schools reopened. Whether the impact of school closures on learning varies with the school's administration level is still an open question in the literature. However, there are several papers that point to the benefit of a decentralized management on the provision of education (Galiani et al. (2008), Faguet (1999), Jimenez and

Sawada (1999), Filmer (2002), King and Ozler (2000)). Having a policymaker close to the population helps the identification of households' needs. In the context of school shutdowns, parents of children enrolled in locally-managed schools have lower transaction costs of putting pressure on the local authority administration to take actions aimed to help students catch up with the school curriculum.

1.6.1 Robustness checks

Locally-managed network

In the municipalities that opted not to extend the winter break, 11% of the contracted teachers in their locally-managed schools also worked for the state-managed network, whose schools were closed.[33] Therefore, one may argue whether the impact of the shutdowns is underestimated as it is possible that part of these teachers opted not to lecture while state schools remained closed, making students from the locally-managed network miss school content even though the municipal government opted not to extend their winter break. To deal with this, I add as control the percentage of teachers working in a state and a locally-managed school (columns 2 of Table 1.3). The estimates are very similar to the baseline specification presented in columns 1 of Table 1.3.

As pointed out in Section 1.5, the DiD analysis is run on a sample of locally-managed schools. Therefore, none of these schools were included in the state government's managerial practices program implemented in 2008 and 2009. However, there are teachers of the locally-managed network that also worked in a state-managed school where the intervention was implemented. This is the case for 5.4% of teachers in locally-managed schools that extended the winter break, and for 1.3% of teachers in the comparison municipalities. Even though the percentages are small, if these teachers took better managerial practices to the locally-managed schools, the estimates are likely to be biased. I then add as control the percentage of teachers that also work in a state-managed school that implemented the state-government intervention. The point estimate is lower in absolute terms as shown in columns 3 of Table 1.3, but not statistically different from the baseline specification (columns 1 of Table 1.3).

[33] Census of Education, 2009.

State-managed network

As discussed in Section 1.5, the triple difference regression considers the sample of state and locally-managed schools in the municipalities that opted to extend the winter break ($G = 0$) and in the municipalities that followed the school calendar as previously planned ($G = 1$). To not confound the school shutdowns with the managerial practices program implemented by the São Paulo state government in 2008 and 2009, I exclude from the analysis all the 621 schools where this intervention was implemented. However, 18% of the teachers of the sample of state-managed schools also worked in a participating school of the managerial practices program. Therefore, since one may argue whether these teachers could offset the impact of the shutdowns, I run an additional specification adding the percentage of teachers in this situation as a control variable. The results are very similar to the baseline estimate (columns 5 and 4 of Table 1.3).

It is interesting to notice that the first DiD of the triple differences model is run on the sample of state and locally-managed schools of the 112 municipalities ($G = 1$). The comparison here is among state schools that extended the winter break with the municipal schools that remained open (Equation 1.3 and Table 1.2). As pointed out in the previous paragraphs, there is a small percentage of teachers in these municipalities that work for both networks, which could bias the estimates. I then test a specification adding the percentage of teachers in this situation as a control variable. The point estimate is smaller, but not statistically different than the baseline one (columns 6 and 4 of Table 1.3).

The second DiD of the triple difference model considers the schools in the 10 municipalities ($G = 0$) where both state and locally-managed schools were closed (Equation 1.4 and Table 1.2). Therefore, one may wonder whether the second DiD estimate is capturing both the time trend gap between these two school networks (α_5), but also how each school network reacted to the shutdowns. If, on the one hand, the educational indicators of locally-managed schools are on average better than the ones of the state-managed network in $G = 1$ (Table A.4 and Table A.8), on the other hand, descriptive statistics presented in Table A.5 and A.9 suggest that the state-managed network are on average better than the local ones in $G = 0$. For instance, the percentage of principals who perceive teacher absenteeism as a big issue is 11 percentage points lower in state-managed schools than in locally-managed schools. On average, these state schools had longer school days than locally-managed ones (5.2 hours vs. 4.7 hours) and lower teacher

absenteeism. In $G = 0$, state-managed schools also seemed to be better prepared in terms of the availability and quality of textbooks.[34]

To deal with the aforementioned issue, in addition to controlling for schools, principals, teachers, and students' characteristics, I run a model including school fixed-effects. In doing so, I control for time-invariant unobserved school characteristics seeking to attenuate any biases accruing from heterogeneity in schools' response to the shock. I can see that the point estimates are smaller, but not significantly different from the baseline ones (columns 8 and 4 of Table 1.3.)

1.6.2 Potential Mechanisms

I find evidence that a relatively small period of school shutdowns (2 to 3 weeks) caused by the 2009 H1N1 outbreak led to a significant decrease in students' proficiency in math, equivalent to at least 0.18 of a standard deviation in locally-managed schools and 0.25 in state-managed ones. For Portuguese, the estimated decrease is restricted to the state-managed network and is equivalent to at least 0.18 of a standard deviation.

The magnitude of the effect, besides reflecting the short time frame to cover the school curriculum, might also reflect other factors associated with the pandemic context. It could be that teachers, parents, and students were not entirely comfortable with in-person classes soon after the schools reopened. More stressed teachers and students could negatively affect the quality of the classes, student-teacher, and peer-to-peer interactions at school. Although I do not have any data to test these hypotheses directly, I highlight a few differences on the school management side and on the availability of resources that might elucidate the different responses of state and locally-managed schools.

In the following analysis, I dig into the heterogeneous effects of the shutdowns by interacting the treatment status with the ratio of students per teacher, teachers' perception of principals' managerial skills, teacher absenteeism, percentage of fifth-graders with age-grade distortion, percentage of teachers with the adequate university degree to teach Portuguese and Math, and whether the teachers always correct students' homework. I then run a regression of learning

[34] the percentage of teachers that classify the textbooks as great is six percentage points higher, and the percentage of principals stating there is a lack of textbooks is 26 percentage points lower.

on the school closure dummy, the above-mentioned interactions, and controls aiming to assess whether the effects of the shutdowns were either mitigated or exacerbated by those factors.

I also present descriptive statistics highlighting the differences between municipalities, as well as differences between state and locally-managed schools within municipalities. By doing this, I aim to shed light on how school staff and students dealt with the negative shock.

School principals

The principal managerial skills is an index ranging from 0 to 1. It is calculated based on teachers' answers of how frequently they believe that the principal pays attention to students' learning, administrative norms, and school maintenance; motivates the teachers and encourage new ideas, and take into consideration teachers' inputs; and whether teachers trust the principal and can participate of the decisions related to their work. I test if schools in which principals have better managerial skills were better able to cope with the shutdowns.

For the state-managed network, I find suggestive evidence that better-prepared principals can attenuate the negative impacts of the shutdowns (Table 1.4). A 10% increase in principals' managerial skills is associated with a negative impact on math proficiency 0.5 points smaller on a SAEB scale, equivalent to five school days, or an effect 11% smaller than the average effects of the baseline specification.[35] For Portuguese, the same increase in principals' managerial skills is associated with an effect being 8% smaller.[36]

[35]The baseline triple difference in differences specification estimates a decrease in math performance of -3.5 points in SAEB scale (Table 1.3). As mentioned earlier, the principal managerial skills is an index ranging from 0 to 1. I propose an exercise comparing a school in which the principal managerial skills is 0.91 and another in which the index is 1, therefore, 10% higher. *Ceteris paribus*, the effect of the shutdowns in a school where the principals' managerial skills reach 0.91 is equal to -3.1 points on a SAEB scale $(-8.3 + 5.7 \times 0.91)$, whereas in a school in which the index reaches one, the effect is equal to -2.6 $(-8.3 + 5.7 \times 1)$. Therefore $-2.6 - (-3.1) = 0.5$. Since in 200 schools days, students are supposed to increase their proficiency in 20 points, the 0.5 estimate is equivalent to 5 school days (200 school days $\times$ 0.5/20 = 5 days).

[36]I perform the same exercise. $-5.4 + 3.5 \times 1 - 5.4 + 3.5 \times 0.91 = 0.3$. Since the baseline estimate for the decrease in Portuguese proficiency is 3.5 on a SAEB scale, the 0.3 difference is equivalent to 8%.

Table 1.4: Principals heterogeneity on the impact of school shutdowns on students' learning, fifth-grade

Effects of school shutdowns on the locally-managed network						
		Math			Portuguese	
	DiD	DiD	DiD	DiD	DiD	DiD
	(1)	(2)	(3)	(1)	(2)	(3)
H1N1	-2.83**	-4.46	-2.62*	-0.34	-1.05	0.1
	(0.02)	(0.15)	(0.07)	(0.72)	(0.60)	(0.95)
H1N1 versus		2.3			1	
principal managerial skills		(0.40)			(0.77)	
H1N1 versus			-0.02			-0.35
program to reduce dropout			(0.98)			(0.67)
N. schools	3808	3808	3753	3808	3808	3753
R2	0.8	0.8	0.8	0.8	0.8	0.8
Effects of school shutdowns on the state-managed network						
		Math			Portuguese	
	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD
	(1)	(2)	(3)	(1)	(2)	(3)
H1N1	-3.99***	-8.25***	-3.56***	-2.73**	-5.38***	-1.81
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.11)
H1N1 versus		5.65**			3.53**	
principal managerial skills		(0.04)			(0.05)	
H1N1 versus			-0.29			-0.78
program to reduce dropout			(0.61)			(0.12)
N. schools	5032	5032	4945	5032	5032	4945
R2	0.7	0.7	0.7	0.6	0.6	0.6

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10% critical level. p-value in parenthesis. 95% CI in brackets. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. All regressions include as controls: (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented.

Teachers

Teacher absenteeism is an important issue among schools impacted by the shutdowns.[37] School principals of locally-managed schools of the municipalities that extend the winter break are almost 20 percentage points more concerned with teacher absenteeism compared to the comparison group (Table A.7). In the 112 municipalities where the state network was closed and the local one remained open, the percentage of principals that saw teacher absenteeism as a big concern was 11 percentage points. higher in the state-managed schools than in the local ones (Table A.8). Therefore, one may wonder whether the effects of the shutdowns were augmented by the higher absenteeism.

For the state-managed network, I find evidence that teacher absenteeism exacerbated the impact of the shutdowns on math and Portuguese proficiency by roughly 2 points in the SAEB scale (Table 1.5). The estimated learning loss in math and Portuguese in a school in which the principal sees teacher absenteeism as a big issue is 60% and 90% higher compared to schools in which the absenteeism is not a concern, respectively.[38]

Even with the shutdowns, the percentage of teachers in the state-managed network that covered at least 80% of the school curriculum is not statistically different from the locally-managed network that remained open (Table A.8). Even with the shutdowns and higher teacher absenteeism, these schools seemed to have rushed to cover the school curriculum. Also, part of the textbook was probably given by substitute teachers, to whom students were not used to, making it challenging for them to keep pace with it.

[37] Teacher absenteeism is a dummy equal to 1 if the principal sees teacher absenteeism as a big issue and 0 if the principal sees it as a moderate or small issue.

[38] The estimated decrease in math and Portuguese performance in a school where teacher absenteeism is not a concern is -3.4 and -2.1, respectively. If the teacher absenteeism is a concern, the estimates are equal to -5.4 (-3.4 - 2) and -4 (-2.1 - 1.9), therefore, 60% and 90% higher, respectively.

Table 1.5: Teachers' heterogeneity on the impact of school shutdowns on students' learning, fifth-grade

Effects of school shutdowns on the locally-managed network								
			Math				Portuguese	
	DiD	DiD	DiD	DiD	DiD	DiD	DiD	DiD
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
H1N1	-2.83**	-3.33	-2.30*	-4.29	-0.34	0.22	-0.05	3.35
	(0.02)	(0.17)	(0.06)	(0.14)	(0.72)	(0.93)	(0.98)	(0.36)
H1N1 versus		0.02				-0.03		
students per teacher		(0.89)				(0.82)		
H1N1 versus			-1.91				-1.08	
teacher absenteeism			(0.55)				(0.85)	
H1N1 versus teachers that				0.02				
correct Math homework				(0.47)				
H1N1 versus teachers that								-0.05
correct Portuguese homework								(0.24)
N. schools	3808	3808	3808	3984	3808	3808	3808	3808
R2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Effects of school shutdowns on the state-managed network								
			Math				Portuguese	
	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD	Triple DiD
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
H1N1	-3.99***	-4.03**	-3.37***	-13.57***	-2.73**	-3.06**	-2.14**	-5.18
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.03)	(0.04)	(0.15)
H1N1 versus		0				0.02		
students per teacher		(0.99)				(0.71)		
H1N1 versus			-2.03*				-1.92**	
teacher absenteeism			(0.05)				(0.03)	
H1N1 versus teachers that				0.11*				
correct Math homework				(0.06)				
H1N1 versus teachers that								0.03
correct Portuguese homework								(0.53)
N. schools	5032	5032	5032	5232	5032	5032	5032	5032
R2	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10% critical level. p-value in parenthesis. 95% CI in brackets. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. All regressions include as controls: (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented.

Length of the school day and quality of the textbooks

The fact that the state-managed network was able to cover as much school content as the locally-managed network that remained open can be also explained by the longer length of their school day (5.3 hours × 4.9 hours). The 24-minute daily difference might have helped to compensate part of the period of the shutdowns. This difference is equivalent to an addition of three to four school days in the whole school year compared to locally-managed schools (Table A.4).[39]

However, the additional time in the classroom due to the longer duration of the classes in the state-managed schools is still inferior to the lost time in the classroom due to the period of the shutdowns. Also, I do not find any indication that the state government extended the length of the school year to compensate for the days the schools were closed. In fact, the length of the school year was five days longer in the locally-managed network (Table A.4). These statistics also suggest that teachers of the state-managed network had to rush to cover the school curriculum, making it challenging for the students to keep pace with it.

A glance at the descriptive statistics presented in Table A.3 also highlights the challenges faced by the locally-managed schools affected by the shutdowns. One of the issues that stands out is that these schools were not able to cover the school curriculum in a shorter time frame. While 55% of locally-managed schools in municipalities that did not extend the winter break covered more than 80% of the school curriculum, only 45% did so in municipalities affected by the school closures.

Data from the Prova Brasil questionnaire show that teachers faced many barriers to covering the entire school curriculum successfully. For instance, students in treated schools had fewer hours of classes per day (4.8 hours × 5 hours). The 12-minute daily difference resulted in children from the affected schools having two days less of school content between the reopening of the schools and the proficiency test.[40] Also, I do not find any indication of extension of school days

[39]There are between 44 and 53 business days between the reopening of the schools (August 17, 2009) and the proficiency test (which took place between October 19 and October 31, 2009). Therefore, the 24-minute difference would result in 1,056 to 1,272 additional minutes of class, equivalent to 17.6 to 21.2 hours. If the average number of class hours in the state-managed network in $G = 1$ is 5.3, the estimate in terms of school days is between three and four.

[40]There are between 44 and 53 business days between the reopening of the schools (August 17, 2009) and the proficiency test (which took place between October 19 and October 31, 2009). Therefore, the 12-minute difference would result in 528 to 636 fewer minutes of class, equivalent to 8.8 to 10.6 hours. If the average number of class hours in the affected network is 4.8, the estimated school days are roughly two.

later in the year to account for the missing days during the winter break extension. The length of the school year was actually shorter in the affected network (Table A.3).

The availability and the quality of textbooks also seem a concerning point when the locally-managed network affected by the shutdowns is compared to the unaffected one. the percentage of teachers satisfied with the textbooks was 3.5 percentage points lower in treated schools, whereas the percentage of principals complaining about the lack of textbooks was 22.5 percentage points higher. The elevated teacher absenteeism (18 percentage points higher compared to the unaffected schools) and the lack of proper high-quality textbook materials suggest that the treated schools dealt with more challenges to mitigate the learning loss caused by the school closure. Also, the higher student absenteeism (4 percentage points) in affected schools means that one missing day in school implies more loss of instruction (Table A.7).

1.7 Discussion and Conclusion

The decision to close schools in a pandemic faces a clear trade-off: on the one hand, this policy seems an efficient measure to reduce infection rates among students (Adda (2016)). On the other hand, its long-term consequences can be daunting to a whole generation of youth learners, particularly the most vulnerable.

In the state of São Paulo, Brazil, amid the H1N1 outbreak in 2009, more than half of the public primary and secondary schools were closed between two to three weeks, affecting more than 5.5 million students. I leverage this natural experiment to estimate the impact of school closures on the proficiency of fifth-graders in Portuguese and math. In each one of the 645 municipalities of the state, the state government and the respective municipal government share the responsibilities for the provision of public education. The way the policy was implemented, allows me to investigate the impacts of the school shutdowns on the schools managed by the state government, state-managed, and on the schools managed by the local authorities, the locally-managed.

I find evidence that the school shutdowns led to a reduction in math scores of at least 0.18 of a standard deviation in locally-managed schools and 0.25 in state-managed ones, equivalent to at least six weeks of learning loss. For Portuguese, the effects are restricted to schools managed by

the state authority and reach at least 0.18 of a standard deviation, suggesting that the locally-managed schools were better able to respond to the students' needs when schools reopened. Parents of children enrolled in locally-managed schools have a lower cost of putting pressure on the local authority administration for students to catch up with the missing curriculum. The more detrimental effects in math might be associated with the fact that during school breaks, families tend to focus more on the promotion of literacy skills at home, which indicates why the quality of the schools potentially has more significant effects on math than on reading.

I compare students that were away from school for two weeks, the length of students' winter break, with students that spent between four to five weeks without going to school, which was the length of the winter break together with the school shutdowns. Since the more the period away from school, the more detrimental is the loss of learning skills, my estimates also reflect the learning slide that occurred during school breaks.

The quantile estimates on math test scores indicate that the effects of school closures were higher in the schools at the bottom of the math test score distribution. The effects being higher among low-performers help explain the relatively small increase in the percentage of students below the minimum level of math proficiency (4.6% and 8.7% in locally and state-managed schools, respectively). Hence, the results indicate that the shutdowns hit harder on those lagging behind even before the pandemic struck. The data show that these low-performer schools had higher repetition and dropout rates, suggesting that the effects were higher among vulnerable students.

A pandemic outbreak might affect children's skills in various ways. A context of a pandemic that involves death, income loss, unemployment, insecurity, social isolation, and increased exposure to domestic violence can have meaningful negative consequences on children's socio-emotional skills and well-being. The Global Education Monitoring Report (2019) points to the disruptive effects on learning as physical; emotional, with anxiety, fear, sadness, and lack of emotional control; and cognitive, expressed via difficulty to pay attention, inability to process information, and memory problems. As emotionally nurturing environments produce more capable learners, these factors will have more profound consequences for children's cognitive development (Cunha and Heckman (2007)). Given that all these factors affect learning, the estimates could be also capturing these indirect effects caused by school closure on student learning.

For instance, the risk of contagion and the average number of hospitalizations were higher among the municipalities whose local authority imposed school closures. It could be that parents and guardians were more reluctant to send children back to school, causing them to miss more school days. After the Influenza outbreak in 1918, around 200 thousand students were absent even after the schools reopened in New York City (Meyers and Thomasson (2017)). After the Ebola outbreak in 2014, 9 out of 10 people interviewed in Ghana by the United Nations confirmed the reduction in school attendance (United Nations Development Group (2015)).[41] The fear of contagion could also have affected the leisure activities of students, potentially triggering psychological factors such as anxiety and depression with clear implications to cognitive development.

The expressive learning losses detected during a relatively small period of school shutdowns amid the H1N1 outbreak illustrate the challenges policymakers face to design public policies capable of counterbalancing the short and longer-term consequences of school shutdowns. To give context to the challenges facing the school system, I use a meta-analysis conducted by McEwan (2015) that summarizes the impacts of more than 70 randomized controlled trials of educational interventions in developing countries. According to the author, the school interventions in primary education have, on average, positive effects that range from 0.05 to 0.15 of a standard deviation. The effect of the most effective intervention is smaller than my lowest estimate.

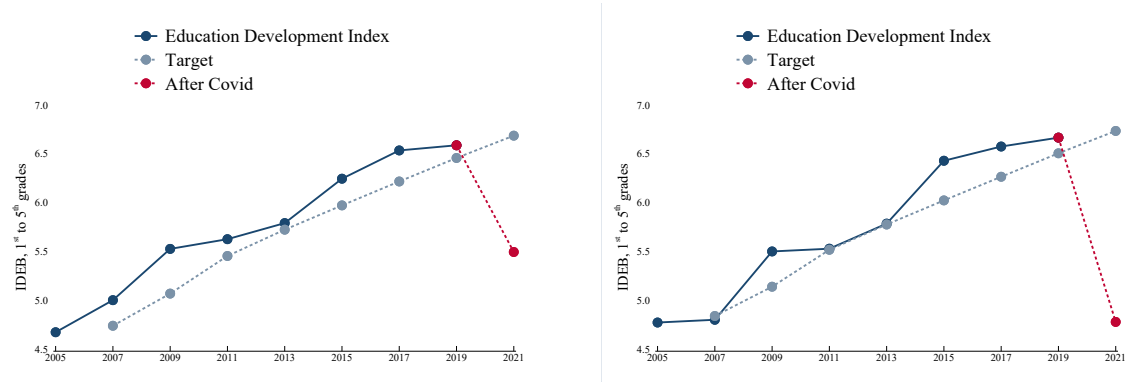
Unlike in 2009, school shutdowns amid the Covid-19 are partially being mitigated by remote learning. However, this is a sub-optimal solution as many children lack computers, access to high-speed internet, a suitable environment for studying, an adult who can help with the new teaching routine and will not be able to benefit from student-teacher and peer-to-peer interactions. Moreover, even with adequate resources, not all the teachers were capable to teach remotely (Rogers and Sabarwal (2020)). The Centro de Estudios de Ministerio de Educación de Chile (2020) estimates that distance education could only mitigate around 30% of the learning loss due to a 6-month school shutdown, and the percentage drops to 18% in public schools.[42]

[41] The United Nations carried out an anthropological survey to capture people's practical experiences of the socioeconomic impact of the Ebola pandemic in Guinea. See the report in this link: https://ebolaresponse.un.org/socio-economic-impact-ebola-west-africa-pdf.

[42] Some estimates are also available in this link: https://observatoriodeeducacao.institutounibanco.org.br/cedoc/detalhe/89499b7c-6c99-4333-937d-1d94870d3181

I use my estimates to shed some light on the potential causal impacts of the school shutdowns in the state of São Paulo amid the Covid-19 outbreak. I acknowledge that the current pandemic outbreak is being way more detrimental to individuals' lives than the H1N1 and the period of the shutdowns is significantly longer. The measures adopted to contain the spread of the current outbreak are incomparable. The economic shrink, the long period of social isolation, and the grief after losing a relative or friend are likely to trigger emotional disorders, affecting parents, teachers, and children. Thus, the attempt to proxy the impacts of the Covid-19 on children's learning using my estimates is imperfect, reliant on strong assumptions and should be seen as a lower bound estimate of the learning loss.

Assuming that the remote learning mitigates 30% of the learning loss, I estimate that the 56-week shutdown would lead to a drop in proficiency equivalent to all the learning accumulated since 2007 and 2009 by an average student of the state and locally-managed networks, respectively (Figure 1.3).



(e) Locally-managed (f) State-managed

Figure 1.3: Estimated drop in IDEB after the school shutdowns amid the Covid-19

Note: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. I adopt the following assumptions to estimate the decrease in IDEB: first, that the school shutdowns lasted for 56 weeks. Second, a decrease in the standardized proficiency in Portuguese and Math of 0.09 (in a scale from 0 to 10) in locally-managed schools and of 0.15 in state-managed schools (Check the estimates in Table A.15). Third, that the online classes would only mitigate 30% of the learning loss. Fourth, that the grade promotion rates remain constant. Check the code to replicate the results: https://github.com/worldbank/h1n1-school-closures-sp-2009.

The long period of school shutdowns will have deep consequences for primary school students, particularly in public schools. As student learning is cumulative, if children are not able to acquire the adequate set of skills in elementary school grades, they might not catch up with school curriculum in final grades. Not being able to follow the class may lead to increase in school dropouts, implying lower learning trajectories for a whole generation (Crouch and

Gove (2011), Rogers and Sabarwal (2020)). Reduced human capital for disadvantaged children could perpetuate intergenerational transmission of poverty and inequality (Rogers and Sabarwal (2020)). Given that Brazil's North and Northeast regions concentrate the poorest states and the worst public schools in the country, it is reasonable to expect that the current pandemic crisis to hit harder those two country regions. Remediation and well-targeted policies will be critical to overcome the educational system's challenges.

2 *Teaching at the Right Level*: evidence from the Program *Acelera* in Brazil

2.1 Introduction

In primary education, children built the foundation skills on which their future learning will be based on (Crouch and Gove (2011)). An adequate set of reading and numeracy skills helps them to achieve their full potential which can lead to major life-long consequences, such as better job opportunities and breaking the intergenerational cycle of poverty (Akresh et al. (2018)).

Developing countries have made huge progress in universalizing access to primary education. According to UNICEF, the net primary enrollment rate for children aged between 6 and 11 years old reached 90% in 2019, and 80% of them complete this level of education.[43] However, there are still challenges to overcome. According to the World Bank, even before the Covid-19 outbreak, more than half of the children living in developing countries were not able to read and understand a basic text by age 10.[44] As a consequence of the school shutdowns that took place during the pandemic, this number is expected to rise by at least 10%.

Children's low proficiency can be explained by several factors such as having a disadvantaged socioeconomic background, the lack of qualified teachers and textbooks, bad school infrastructure, and a high opportunity cost of going to low-quality public school versus joining the labor market and complementing their households' income. Also, children have to learn a demanding curriculum, regardless of their level of preparation. Since knowledge is cumulative, those who fail to achieve the right set of skills in elementary education will struggle to learn in the later grades and may never catch up (Crouch and Gove (2011)). This scenario might lead to repetition, dropout, and, as a consequence, an increase in age-grade distortion, characterized by children being older than the adequate age for the grade they are enrolled in.

In this context, some countries have implemented an intervention called *Teaching at the Right Level*, which aims to build the basic reading and math skills in children that are well behind the expected level of achievement for the grade they are enrolled in (Banerjee et al. (2016)).

[43] https://data.unicef.org/topic/education/primary-education.
[44] https://www.worldbank.org/en/topic/education/brief/what-is-learning-poverty.

The idea is to group children, not according to their age, but according to their proficiency (Banerjee et al. (2017)). These children are then allocated for a few hours in a separate class.

The main benefit of the *Teaching at the Right Level* is to provide a class where the curriculum is tailored to match the learning levels of the students who are not able of following the standard curriculum. Children may feel more comfortable in classes where their peers have similar performance (Banerjee et al. (2007)), and where they are able to keep pace with the subjects being taught. The intervention can even benefit children who were not directly targeted. Removing low-performers drops the pupil-teacher ratio in the students' original class, and may allow teachers to focus on more advanced material.

The program *Acelera* in Brazil is one example of *Teaching at the Right Level*. The intervention was developed by Ayrton Senna Institute, a non-profit organization. The program was first implemented in 1997, the year in which more than 40% of primary education students were at least one year older than the adequate age for their grade (age-grade distortion), dropout rates reached more than 9% and grade-retention was 13%.[45] Since then, *Acelera* has reached almost 25% of the Brazilian municipalities, one million children, and 33 thousand educational professionals.[46]

Acelera targets primary education students with low performance and who are at least one year older than the adequate age of their grade. The program aims to increase learning levels, and grade promotion, and decrease dropout and age-grade distortion. The ultimate goal of *Acelera* is making children jump up to two grades, so third-grades could jump up to fifth-grade, fourth-graders to sixth-grade, and fifth-graders to seventh-grade, boosting the reduction of the age-grade distortion.

In the municipality of Recife, in the state of Pernambuco/Brazil, the state government, whose representative is the Governor, and the municipal government, whose representative is the mayor, provide public primary education. According to the 2020 Census of Education, the municipal government is in charge of 205 primary schools (locally-managed schools), and the state government has only two primary schools under its management (state-managed schools). The main roles of the state municipal Departments of Education are to implement

[45] Census of Education, 1997.
[46] Check the numbers in the link: https://institutoayrtonsenna.org.br/pt-br/como-atuamos/acelera.html.

programs aimed to improve students' learning or reduce dropout, grade-retention, and age-grade distortion, hire teachers, provide textbooks, appoint principals, and finance school infrastructure, among others.

Since 2010, the municipal Department of Education, in partnership with Ayrton Senna Institute, decided to implement *Acelera* in their locally-managed schools. By 2018, more than eight thousand students had received the intervention, a number that represents 13% of primary education enrollments with at least one year of age-grade distortion.[47] Nine out of ten beneficiaries were either enrolled in fourth or fifth grade and around two-thirds of the locally-managed schools in Recife implemented the program in at least one year between 2010 and 2018.[48]

I employ a difference-in-differences (DiD) approach on a rich dataset at the student level to assess the impact of *Acelera* from 2010 to 2018. I compare the program participants, the *treatment group*, with students that, although eligible to participate, were not included in the intervention, the *comparison group*. To have more comparable groups, I run a propensity score matching on the sample of eligible students and only kept those in the common support in the DiD.

To estimate the effects of *Acelera* on students' proficiency in Portuguese and math, due to the availability of the data, I rely on students that joined the intervention in the fourth grade. Up to 2015, third and fifth-graders were the primary education students that answered the standardized exam to assess students' performance and that is applied by the state of Pernambuco. Hence, by focusing the analysis on fourth graders, I can compare the proficiency of participants and non-participants before the intervention, when they were in third grade, and after the intervention, when in fifth grade. In this sense, I restrict the sample to fourth-graders whose proficiency data is available for both third and fifth grades. I standardized the students' proficiency so that the treatment effect could be measured in terms of standard deviations (SD). The use of the standardized measure prevents the analysis from being scale-sensitive and allows for comparability between grades and with other studies.

[47] Between 2010 and 2018, the locally-managed schools of Recife registered 64,440 primary education enrollments of students with at least one year of age-grade distortion (Table 2.2).

[48] Information for locally-managed schools. This chapter does not contain information on schools managed by the state government of Pernambuco, since the state authority did not implement *Acelera* in schools under its management.

I find evidence that the program increased proficiency in Portuguese and Math by 0.05 standard deviation. Although the impact seems low when compared to similar interventions, such as 0.6 sd in India, 0.24 sd in England, 0.15 sd in Ghana, and 0.09 sd in the United States (Banerjee et al. (2007), Gorard et al. (2017), Duflo et al. (2020), Fryer Jr and Howard-Noveck (2020)), I believe that the estimate is a lower bound of the true impact of the program. *Acelera* allows students to jump up to two grades and this was the case for one-third of fourth-grade participants. These students went right to sixth grade and ended up not doing the standardized proficiency assessment while in fifth grade (when the test is applied). Under the reasonable assumption that the ones that jumped two grades are among the best performers, I end up underestimating the true impact of the intervention.

To estimate the impact of *Acelera* on grade promotion and dropout rates, the data available allows me to follow a panel of first to fifth-graders. I find evidence that the program not only increased grade promotion in the year of participation but also in the years after that. The results show an increase in grade promotion of 15 percentage points, equivalent to 0.3 of a standard deviation. Also, I find some evidence that treated students are less likely to drop out in the year of the intervention.

To my knowledge, this is the first work to assess the impact of *Acelera* on students' proficiency in Recife. The contributions of my work are twofold. First, it provides treatment effects estimates for the biggest *Teaching at the Right Level* intervention ever implemented in Brazil. Second, it contributes to a growing literature on remedial education policies that are critical in the context of the huge decrease in students' performance during the Covid-19 outbreak.

Apart from this introduction, this chapter is organized as follows: Section 2.2 presents the related literature. Section 2.4 summarizes *Acelera* . Section 2.4 introduces the data available to perform the analysis. Section 2.5 discuss the empirical strategy. Section 2.6 presents the preliminary findings. I then conclude in Section 2.7.

2.2 Related Literature

Students with low proficiency levels face more difficulties in absorbing school content, which might lead to repetition, dropout, and, as a consequence, an increase in age-grade distortion

(defined as the percentage of students that are at least one year older than the adequate age for the grade they are enrolled in).[49] A higher the percentage of students in this situation increases classroom heterogeneity, which makes it challenging for the teachers to deal with students from such diverse ages and which may weaken peer-to-peer interaction. For the government, higher levels of age-grade distortion increase the inefficiency in the use of public resources as students remain in school for longer than adequate.

The lack of foundation skills is the major source of grade repetition, poor performance in post-secondary education, and high school dropout (Somers et al. (2010)). Hernandez (2011) find evidence that almost 20% of third-graders that did not read proficiently ended up not graduating from high school on time, a rate that was four times higher than the one of proficient readers.

Countries can boost their economic growth and reduce inequalities by expanding access to primary education and improving its quality. School policies can play an important role in increasing the children's cognitive skills (Hanushek and Woessmann (2012)). It is well documented that students' proficiency in reading and math are strongly correlated with labor productivity (Hanushek and Kimko (2000), Ciccone and Papaioannou (2009)). Indeed, Hanushek and Woessmann (2012) estimated that an increase of one standard deviation in cognitive skills of a country's workforce is associated with roughly two percentage points increase in annual per capita GDP.

The *Balsakhi Program* is a world-recognized *Teaching at the Right Level* intervention implemented in India. The program hires young women from children's local community to teach basic literacy and numeracy skills to students falling behind their peers. Children included in the intervention are taken out of their main class for two hours a day and are sent to a class that has 15 to 20 children.[50] The intervention has a standardized curriculum that focuses on the competencies that children should have learned in their two first grades. Banerjee et al. (2007) find evidence that the *Balsakhi Program* had a high impact on the proficiency of the treated students, an estimate that ranges from 0.6 to 1 standard deviation. The authors also tested whether the reduction in the pupil-teacher ratio, caused by the weakest peers being removed from the classroom, benefited students not included in the

[49] In primary education, the adequate age is 6 for first grade, 7 for second grade, 8 for third grade, 9 for fourth grade, and 10 for fifth grade.

[50] According to Banerjee et al. (2007), their whole school day is about 4 hours.

program. The authors did not find evidence that this was the case, corroborating that inputs, when not accompanied by changing pedagogy, may not help.

The *Switch-on Reading* is a 10-week intervention designed for seven graders with low reading performance in England. Students are removed from their main class and taken to a 20-minute session tailored to improve their reading comprehension and fluency. For each student, school staff is assigned, commonly a teacher assistant, to whom they read four books chosen according to their needs. Gorard et al. (2017) find evidence that the program led to an increase in reading skills by 0.24 of a standard deviation, equivalent to three months of learning. The authors also investigate the effects of the intervention at different levels of the proficiency distribution prior to the treatment. Their results suggest that the low performers benefited more, with an effect size of 0.39 of a standard deviation, equivalent to five months.

The *High-Dosage Reading Tutoring* targets middle school students in New York City public schools. The students were grouped by 2.5 hours after the school day for supplemental classes. For a subset of them, the intervention provided a four-on-one reading tutoring section that lasted between 45 to 60 minutes. Fryer Jr and Howard-Noveck (2020) find evidence that the intervention increases the school attendance of black students by 2 percentage points and reading scores by 0.09 of a standard deviation.

The *Enhanced Reading Opportunities* is a literacy program implemented in England that targets ninth graders whose reading skills are at least two years below their grade level. Students, in addition to their regular English classes, are allocated to a 45-minute daily class with other 10 to 15 children. In those classes, teachers work on students' motivation, reading fluency, vocabulary, comprehension, phonics, and writing. Somers et al. (2010) find evidence that the program improved students' reading comprehension by 0.09 of a standard deviation.

The *Teacher Community Assistant Initiative* provided two remedial education interventions for primary students in Ghana. In one of them, a teacher assistant works with remedial learners on a pull-out basis during the school day. On the other, the teaching assistant works with the students outside of the school day. Duflo et al. (2020)'s findings suggest that the programs increased students' test scores by 0.15 of a standard deviation after two years of exposure.

Overall, the available literature focuses on interventions that take students out of their main

class for a few hours during their school day, or that provide extracurricular activities outside the school hours. Also, most of the programs are implemented for a few months or weeks of the school year.

Differently from the previous interventions, *Acelera* selects low performers to be allocated to a different class during school hours during the whole school year. I am aware of only one quantitative study on the impact of *Acelera*. Oliveira et al. (2019) perform a difference-in-differences approach and find evidence that the program increased grade promotion of primary students by 15 percentage points.

My analysis differs from Oliveira et al. (2019) in two main aspects. First, besides grade promotion, I estimate the impact of *Acelera* on students' proficiency in reading and math, and dropout. Second, the authors compare program participants with all the remaining students with at least one year of age-grade distortion not included in the intervention. In addition to that, to have more comparable groups of participants and non-participants, I perform a propensity score matching based on students' grade, sex, the color of the skin, level of age-grade distortion, and whether the student repeated in the previous year.

2.3 The Intervention: *Acelera*

The program *Acelera* targets primary education students who lagged behind their peers and are at least one year older than the adequate age for their grade. The intervention is designed to promote learning practices that are adequate to students' levels of proficiency, making it possible to catch up with the right set of skills for the grade they are enrolled in. By doing that, the program aims to increase learning levels, and grade promotion, and decrease dropout and age-grade distortion. The ultimate goal of *Acelera* is to make students jump up to two grades. In this case, third graders could jump to fifth grade, fourth graders to sixth grade, and fifth graders to seventh grade, boosting the reduction of their age-grade distortion.

The program was created by Ayrton Senna Institute (IAS), which is a non-profit organization founded in 1994 that provides technical support to educational policies aimed to increase the quality of education in Brazil. *Acelera* was first implemented in 1997 by 15 Brazilian municipalities. 25 years after, almost one million students and 33 thousand educational

professionals have participated in this intervention. Since 2010, *Acelera* has been implemented in Recife, a municipality of Pernambuco state in Brazil. In that year, 20% primary education students were at least one year older than the right age for their grade (Table B.1).

Before the beginning of the school year, the Department of Education selects schools to implement *Acelera* based on their number of eligible students and the availability of additional classrooms to accommodate them. Once the schools are selected, the teachers and principals are in charge of selecting the participant students based in their age-grade distortion and on the results of a proficiency assessment applied at the beginning of the school year. The intervention is then introduced to the student's parents, who can decide whether their children will participate or not.

Acelera participants are separated from the students enrolled in regular education. They are sent to a new class for the entire school year, which has a minimum of 200 days a year and 800 hours of instruction. The program is managed by a municipal coordinator, indicated by the Department of Education, whose responsibility is to send monthly reports to Ayrton Senna Institute, monitor students' and teachers' frequency, and ensure that the minimum length of schools days are met. Local supervisors monitor four classes, watching one of their classes per month to help teachers with classes planning and new pedagogic practices.

Teachers participate in training provided by the Department of Education and Ayrton Senna Institute. The training called *Capacitar* consists of 12 video classes of 30 minutes each. The videos contain examples of situations that can be faced by the students during Portuguese, Mathematics, Sciences, History and Geography classes. The recommendation is that the teachers watch the training together, and plan their classes accordingly. Teachers are encouraged to engage students in short-term and small projects, of one or two days, in order that they can actively participate in the learning process and work on their self-esteem as they finished the activities.

Every two weeks, teachers have meetings with local supervisors to discuss program implementation, share experiences, and plan their classes based on the students' needs. Ayrton Senna Institute provides textbooks to the students, the pedagogic material to develop the activities specified in the books, dictionaries, maps, magazines, and technical manuals for

teachers and local supervisors. Table 2.1 introduces the theory of change of *Acelera* .

Acelera faces four main challenges. First, the heterogeneity of the classes as they can have students enrolled in different grades and with diverse levels of age-grade distortion. Second, the stigma of participating in the intervention as students are taken out of the regular class during the whole school year and could be identified as the lower performers. Third, as the participating students can be the more challenging ones, one may wonder whether the best teachers would be willing to teach them. Fourth, the high levels of teacher absenteeism and turnover.

It is important to point out that, in 2001, Ayrton Senna Institute created another program called *Se Liga*, that also targets students with at least one year of age-grade distortion, but focuses on the ones that do not know how to read and write. The IAS designed this intervention after observing that part of the students that joined *Acelera* could not read or do basic math. The *Se Liga* aims to literate students and prepare them to participate in *Acelera* or return to regular education Besides *Acelera*, the municipality of Recife has been implementing the *Se Liga* since 2010. In this work, I do not study the effects of this intervention.

Table 2.1: Theory of Change of *Acelera*

Inputs	Activities	Outputs	Outcomes	Final outcomes
Physical space in the schools to set up *Se Liga/Acelera* classes.	Teachers map potential eligible students based on age distortion and proficiency.	Acelera: teachers cover 4 textbooks with 30 classes each. The books have Portuguese, Math, Geography, History, and Science content.	Classes with fewer students.	Increase of approval.
Teachers to be in charge of these students.	The Secretary of Education selects the schools to offer the intervention.	Se Liga: teachers cover the 42 classes of the student's textbook. This book has Portuguese and Math content.	Classes more homogeneous in terms of proficiency.	Decrease of dropouts.
Mediators to monitor the program's implementation. One mediator is in charge of four classes.	The Secretary of Education and the school's pedagogic team selects the students who will be invited to participate.	Monthly delivery of three and four extracurricular books for Se Liga and Acelera students, respectively.	School curricula in accordance with student's needs and their level of learning.	Decrease in age distortion.
Technical staff in the Secretary of Education to train teachers and supervise the program.	The interventions are introduced to parents, and students are invited to participate.	A school year with a minimum of 200 days and 800 hours.	Increase in student's self-esteem.	Increase of proficiency.
Online teacher training provided by IAS.	Teacher's training before the beginning of the school year.	Effective use of the time. The classes are organized as follows: welcoming of students, reading, correction of the homework, development of new activities, review, and explanation of the homework for the next class.	Increase of teacher and student attendance.	
Textbooks for *Se Liga/Acelera* students provided by IAS.	Student's learning levels are mapped at the beginning o the school year.	Monthly monitoring of proficiency.	Increase in the number of books read.	
Methodological proposal for the program's monitoring provided by IAS.	Once a week, mediators attend the classes of the students they are in charge of.	Monitoring of student's attendance and completion of the homework.	Increase in the % of homework completed.	
	Mediators provide feedback to teachers.	Mediators support teacher's pedagogic planning.		
	Monthly pedagogic meetings with teachers, mediators, and technical staff of the Secretary of Education.	Monthly pedagogical planning involving teachers, mediators, and technical staff of the Secretary of Education.		

2.4 Data

Public and private schools offer primary and secondary education in Brazil. The public system is decentralized and the 26 states, the Federal district, and the 5,570 municipalities share the responsibilities for the provision of public education.[51] Hence, the schools located in all the Brazilian municipalities can be managed either by the state government or can be under the management of the municipal government. The first group of schools is state-managed, and the second group of schools is locally-managed. The main roles of the state and municipal governments are to implement interventions aimed to increase students' performance, hire teachers, provide textbooks, appoint principals, finance school infrastructure, and determine the length of the school day, school breaks, as well as the beginning and the end of the school year in the schools under their responsibility.

Since 1995, all private and public K-12 schools participate in the annual Census of Education. The Census is implemented by the National Institute of Educational Studies and Research (INEP), a research agency under the Brazilian Ministry of Education.[52] The Census collects information on (i) school facilities, such as libraries, sports courts, and science and computer labs; (ii) school infrastructure as filtered water, electricity, and internet access; (iii) social services, for example, school transportation and provision of meals; (iv) students, such as sex, color of the skin, age, physical disabilities or mental illness, grade level, instruction time per day, class-size, subjects they are enrolled in, grade promotion, repetition and dropout rates; and (v) teachers, as educational attainment, age, physical disabilities, subjects taught, and classes they are in charge of.

In 2000, the Department of Education of the state of Pernambuco designed an Education Assessment System (SAEPE) to monitor the performance and grade promotion of primary and secondary students.[53] Proficiency tests in Portuguese and Math are annually applied to second, fifth and ninth graders of state and locally-managed schools across the 184 municipalities of the state. I standardized the students' proficiency, that therefore assume

[51]The 1988 Constitution established that the Federal Government, the 26 states and the Federal District, and the 5,570 municipalities should share the responsibilities for the provision of education. The municipal governments should give priority to early childhood and primary and lower secondary education; and the state governments to primary, lower secondary, and upper secondary education.

[52]INEP stands for *Instituto Nacional de Estudos e Pesquisas Educacionais*.

[53]SAEPE stands for *Sistema de Avaliação da Educação Básica de Pernambuco*.

values from -1 to 1, so that the treatment effect could be measured in terms of standard deviations (SD). The use of the standardized measure prevents the analysis from being scale-sensitive and allows for comparability between grades and with other studies.[54] Children also answer a socioeconomic questionnaire with information on their household infrastructure; parents' educational attainment; incentives from the family to continue studying; whether the teacher corrects their homework, if they already dropped out or repeated a grade; and if they did kindergarten.

The Information Technology company of the municipality of Recife (EMPREL), is in charge of collecting information on locally-managed schools.[55] The EMPREL organizes annual data at the student level containing information on (i) the school and grade of enrollment; (ii) code of classroom, making it possible to identify student's peers; (iii) whether they were included in *Acelera* ; (iv) date of birth, from which one can calculate the difference between their age and the adequate age for the grade they are enrolled in; (v) sex; (vi) whether they attend school in the morning, afternoon or both; and (vii) their status by the end of the school year (promoted to the next grade, repeated, or dropped out). Since each student has an enrollment code, it is possible to follow them during the years.

The EMPREL and SAEPE datasets do not have the same students' identification numbers which would allow me to merge both datasets. In order to do that and identify the proficiency of the students enrolled in locally-managed schools in Recife, I first match the datasets using the students' names, grades, the year the proficiency test was applied, and the INEP code of the school, which is unique in all educational data. For those we could not find in the SAEPE dataset after this first merge, I follow the same strategy but instead of using the whole name of the student, which can differ in both datasets due to typo errors, I use students' first names and date of birth.[56] I am able to match the proficiency data for half of the third graders and two-thirds of fifth graders (Table B.2).

Between 2010 and 2018, *Acelera* had more than 8 thousand participants in Recife and the number of schools offering the intervention significantly increased. In 2010, only 12 schools (5.7%) offered the program. In contrast, in 2018, the number jumped to 94, representing more

[54] Until 2015, the proficiency test was also applied to third graders. After 2015, second graders joined the assessment.

[55] EMPREL stands for *Empresa Municipal de Informática*.

[56] For the students whose the first name has at least three letters.

than 40% of schools in the municipality (Table 2.2). I observe that, on average, *Acelera* schools are bigger, in terms of students' enrollment, have more classrooms available to create additional classes to offer the intervention, and, as expected, have a higher percentage of students with age-grade distortion and lower proficiency scores (Table B.3).

At the beginning of the school year, once the Department of Education selects the schools to implement *Acelera*, I observe that school boards mainly select fourth and fifth graders, as 90% of the treated students are enrolled in these grades. Besides the students' performance on a test applied at the beginning of the school year, which I do not have access to, the main criteria to select the participants is age-grade distortion. Indeed, more than 90% of them have at least one year of age-grade distortion (Table 2.2). In this sense, I define as eligible students those that are at least one year older than the adequate age for the grade they are enrolled in.

In Recife, between 2009, one year before *Acelera* , and 2018, the age-grade distortion and repetition of primary students decreased by more than 40%, and dropouts by two-thirds (Table B.1). The municipality also experienced a significant increase in the proficiency of fifth graders (Figure B.4). To assess whether *Acelera* is associated with the improvement of these educational indicators, I compare the program participants, the *treatment group*, with students that, although eligible to participate, were not included in the intervention, the *comparison group*.

Among the schools that offered *Acelera* , one out of five eligible students were included in the intervention (Table 2.2), creating a significant overlap of program participants and eligible students enrolled in regular education (Figure B.1). I observe that the way the program was offered allows two comparison groups to which *Acelera* students can be compared to. The first comparison group are eligible students enrolled in regular education in locally-managed schools that offer *Acelera*. The second comparison group are eligible students in the remaining locally-managed schools in Recife, the ones that did not offer *Acelera*.

Table 2.2: Sample of the study, Recife

	Regular school		Acelera schools				Acelera Enrollment by grade				
	N. schools	Enrollment	N. schools	Enrollment by type of education		Enrollments in Acelera with at least one year of age-grade distortion	First grade	Second grade	Third grade	Fourth grade	Fifth grade
				Regular	Acelera						
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
2010	200	10,022	12	573	251	235	2	3	15	63	168
as %			5.7	70.9	31.1	93.6	0.8	1.2	6.0	25.1	66.9
2011	166	7,120	45	1,737	666	582	5	7	59	267	328
as %			21.3	74.9	28.7	87.4	0.8	1.1	8.9	40.1	49.2
2012	149	6,353	62	2,954	947	834	6	18	85	355	483
as %			29.4	78.0	25.0	88.1	0.6	1.9	9.0	37.5	51.0
2013	171	7,276	52	2,890	942	827	13	10	93	436	390
as %			23.3	77.8	25.3	87.8	1.4	1.1	9.9	46.3	41.4
2014	193	8,945	31	1,961	551	496	0	10	54	274	213
as %			13.8	79.8	22.4	90.0	0.0	1.8	9.8	49.7	38.7
2015	168	8,123	51	3,400	850	790	1	24	124	346	355
as %			23.3	81.1	20.3	92.9	0.1	2.8	14.6	40.7	41.8
2016	146	6,425	73	5,321	1,117	1,053	0	33	101	443	540
as %			33.3	83.5	17.5	94.3	0.0	3.1	9.6	42.1	51.3
2017	132	5,465	86	5,748	1,454	1,374	1	52	206	585	610
as %			39.4	80.7	20.4	94.5	0.1	3.6	14.2	40.2	42.0
2018	124	4,711	94	5,837	1,627	1,532	4	42	243	659	679
as %			43.1	79.2	22.1	94.2	0.2	2.6	14.9	40.5	41.7
Total		64,440		30,421	8,405	7,723	32	199	980	3,428	3,766
as %					22.0	91.9	0.4	2.4	11.7	40.8	44.8

Notes: EMPREL/Recife. Column I: number of schools that only offered Regular Education. Columns II and IV: enrollment of primary students with at least one year of age-grade distortion in regular education. Column III: number of schools that offered regular education and *Acelera* . Column V: enrollment of primary students in *Acelera* . Column VI: enrollment of primary students with at least one year of age-grade distortion in *Acelera* . Columns VII to X: enrollment of *Acelera* students by grade.

To assess the impact of *Acelera* on grade promotion and dropout rates, I work with a pooled sample of first to fifth graders from 2008 to 2014.[57] The data allow that since these educational indicators are available for the panel of the students, regardless of the grade they are enrolled in.

However, to investigate the impacts of the intervention on *students' performance*, I need to focus on students that have proficiency data in Portuguese and math available, the one provided by the standardized exam applied by the state government in third and fifth grade only.[58] Therefore, in order to assess the impact of *Acelera* on students' proficiency in Portuguese and math, I work with a sample of students that joined the program in the fourth grade or were eligible while enrolled in that grade but did not participate. This allows me to compare the proficiency of fourth-grade participants and non-participants before the intervention, when they were in third grade, and after that, when in fifth grade. In this sense, I restrict the sample to fourth-graders whose proficiency data is available for both third and fifth grades (Table 2.3).

In the comparison group, approximately 30% follow these criteria and among *Acelera* participants the percentage is 9%. The low percentages are due to a combination of facts. First, I do not find the proficiency scores of all students enrolled in the locally-managed network in Recife, mostly due to typo errors in the students' names. Second, 27% of fourth-graders joined the locally-managed school in this grade or left the network when they were supposed to be in fifth grade, either because of dropout or to enroll in a private school or state-managed school.[59] Third, as the ultimate goal of *Acelera* is to make students jump up to two grades, fourth graders can jump to the sixth grade (Figure B.3). In fact, this was the case for more than one-third of them.

Still, one may other whether among *Acelera* participants there was a selection of the best performers to do the proficiency test. I find evidence that this is not the case. When I compare the students that did the test and the ones that did not, there are no significant differences between grade promotion and repetition rates. Besides that, the third-grade proficiency of absent students is significantly higher, suggesting that the ones who did the test were actually

[57] In 2015 and 2016, 12.4% and 17.7% of students did not have data for grade promotion, repetition, or dropout rates.

[58] The primary education grades to which the standardized exam is applied.

[59] I cannot find these students in the SAEPE assessment as my dataset only have enrollment data for locally-managed schools.

the low performers (Table B.4).

Table 2.3: Sample of fourth graders

	Regular schools				**Schools offering Acelera**								
	At least one year of age-grade distortion				Acelera participants					Regular Education At least one year of age-grade distortion			
	Enrollments 4th grade	% of students with proficiency in: 3rd grade	5th grade	3rd and 5th grade	Enrollments 4th grade	Jumped to 6th grade	% of students with proficiency in: 3rd grade	5th grade	3rd and 5th grade	Enrollments 4th grade	% of students with proficiency in: 3rd grade	5th grade	3rd and 5th grade
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XII
2011	1,281	42.5	52.4	27.4	267	30.0	33.0	12.0	4.5	252	34.5	49.6	20.2
2012	1,332	57.6	45.9	30.6	355	24.5	49.0	15.5	8.5	409	47.4	42.1	24.7
2013	1,364	61.4	60.0	39.8	434	22.1	63.1	13.8	9.0	410	60.7	56.1	38.0
2014	1,351	43.4	51.6	25.3	274	13.9	55.5	19.7	13.1	249	45.0	57.0	29.3
2015	1,418	54.2	56.8	32.9	344	14.2	60.8	19.8	11.6	501	49.3	52.9	28.9
2016	1,262	63.5	73.0	50.2	435	16.6	63.7	21.6	14.9	718	56.4	69.9	42.8
2017	1,073	36.0	69.5	26.3	583	18.0	43.7	15.6	7.5	834	31.1	59.6	21.1
Total	9,081	54.2	56.8	30.6	2,692	18.0	55.5	15.6	9.0	3,373	47.4	56.1	28.9

Notes: EMPREL/Recife and SAEPE/Department of Education of the state of Pernambuco.

2.5 Empirical Strategy

To assess the impact of *Acelera* on students' proficiency in Portuguese and math, grade promotion, and dropout, I explore the main criteria to be included in the intervention. I define as *eligible group* the students that are at least one year older than the adequate age for the grade they are enrolled in. I then compare the program participants, the *treatment group*, with eligible students not included in the intervention, *comparison group* (Table 2.2).

2.5.1 Standard Difference-in-Differences

I first employ a standard DiD specification on a sample of eligible students to estimate the policy impacts:

$$y_{igst} = \alpha_0 + \gamma T_{igst} + \alpha_1 X'_{igst} + \alpha_2 Z'_{gst} + \alpha_3 W'_{st} + \rho_i + \phi_g + \mu_s + \theta_t + \upsilon_{igst} \tag{2.1}$$

In which y_{igst} are the proficiency in Portuguese and Math, grade promotion and dropout of the student i, in grade g, in school s, in year t. T_{igst} is a dummy equal to 1 for the year the student i was included in *Acelera* and in the years after that, and 0 otherwise. Aiming to increase precision and account for potential time-variant confounders, I include a set of controls at the student, grade, and school levels. X'_{igst} are the controls at the student level (sex and difference between students' age and the adequate age for their grade). Z'_{gst} are the controls at grade level (students per class and difference in years between the youngest and the oldest student of the class). W'_{st} are the controls at the school level (library, computer, science lab, internet access, sports court, number of employees, and access to energy and water supply). ρ_i, ϕ_g, μ_s, θ_t are fixed effects for students, grade, school and year, respectively. The parameter of interest, γ, is the average treatment effect on the treated (ATT), that is, the average effect of *Acelera* on its participants. The standard error is clustered at the student level.

Intuitively, the effect of *Acelera* is estimated by comparing the evolution of the educational outcomes of the students that were treated in year t with the comparison ones. In this sense, for grade promotion and dropout rates, the comparison units are the set of eligible students that were never included in the intervention and also the students that had yet not been treated in t.

When the outcome is the proficiency score, since I restrict the analysis to students who either joined the program in the fourth grade or were eligible for it, the effect of *Acelera* is estimated by comparing the performance of treatment and comparison groups before the intervention, when they were in third grade, and after the intervention, when they were in fifth grade.

On the one hand, since not all the schools of Recife offered *Acelera* , this approach allows me to compare similar students where one was enrolled in a school that offered the intervention and the other student was not. Although *Acelera* guidelines specify that an eligible student can change schools to participate in the program, the data indicate that this was only the case for one-fifth of them. On the other hand, since I observe significant differences between regular and *Acelera* schools, one may wonder whether treatment and comparison groups were affected differently (Table B.3). To account for this, I also run the regression in equation 2.1 considering only treated and comparison students of the schools that offered *Acelera* in at least one year between 2010 and 2018.

Another identification threat is the non-observable factors that led to the selection of *Acelera* participants. Besides the age-grade distortion, the school boards select participant students based on their scores on proficiency tests applied at the beginning of the school year, which I do not have access to. Also, not all selected students ended up participating if their parents do not authorize it. To account for these factors, besides controlling for students' fixed effects in equation 2.1, I employ a propensity score matching using the sample of eligible students. For each year t between 2010 and 2018 and grade g, we run the following specification to match *Acelera* participants to similar comparison students:

$$\Pi[Acelera_{igst} = 1/X] = \lambda X'_{igst} + \mu_s + \theta_t + \epsilon_{igst} \tag{2.2}$$

In which $Acelera_{igst}$ is equal to 1 if the student i was included in *Acelera* in t, and 0 otherwise. X'_{igst} are controls at the student level, such as the level of age-grade distortion (the difference in years between students' age and the adequate age of the grade they are enrolled in), whether they have already participated of the *Se Liga* intervention, and if they were promoted to the next grade or repeated in $t-1$. α_s and θ_t are school and year fixed effects, respectively. We then append the sample of matched students, only the ones in the common support, and then

run equation 2.1. Figure B.5 shows that the probability of being treated is very similar for treatment and comparison students.

2.5.2 Leads and Lags

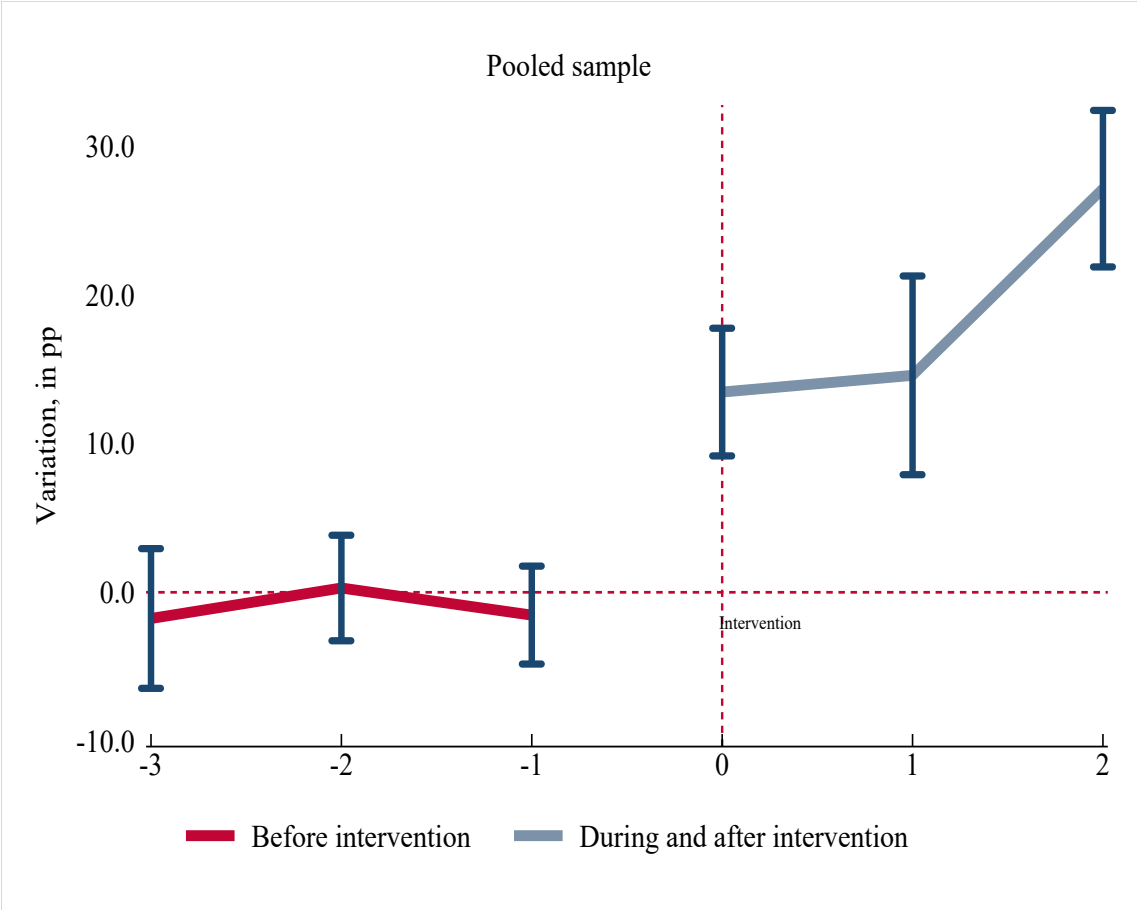
In the second approach to investigate the casual impact of *Acelera* , we explore the fact that the treatment status changes at different times. In the difference in differences methodology, the students are considered treated in the year they receive the intervention and after that, when they returned to regular education. However, for grade promotion and dropout rates, the structure of the data allow me to check whether the treatment status predicts the educational outcomes and not educational outcomes predict treatment status. Consider D_{it} a dummy equal to 1 if the student i was included in *Acelera* in year t, and 0 otherwise. Assume I observe the students for m years after the treatment and q years before it. Angrist and Pischke (2008) suggest the following specification:

$$y_{igst} = \alpha_0 + \sum_{\tau=1}^{m} \beta_{-\tau} D_{i,t-\tau} + \sum_{\tau=1}^{q} \beta_{-\tau} D_{i,t+\tau} + \alpha_1 X'_{igst} + \alpha_2 Z'_{gst} + \alpha_3 W'_{st} + \rho_i + \phi_g + \mu_s + \theta_t + \upsilon_{igst} \quad (2.3)$$

In which $D_{i,t-\tau}$ and $D_{i,t+\tau}$ assume value 1 in τ periods after/before the treatment, respectively, and 0 otherwise. Therefore, the specification allows for m lags (β_{-1},β_{-2},....,β_{-m}) or post-treatment effects and q leads (β_{+1},β_{+2},....,β_{+q}) or anticipatory effects. The lags make it possible to check whether the effects of *Acelera* grow or fade as time passes; and if we believe that $D_{i,t}$ causes Y_{igst} and not vice versa, the leads should not matter in equation 2.3. As with the standard difference-in-differences approach, we run the leads and lags framework on the overall sample and on the sample of matched students, respectively.

I observe that, for the sample of matched students, there are no significant differences in grade promotion rates of participants and non-participants prior to the intervention (Figure 2.1)

Figure 2.1: Leads and lags estimates for grade promotion, sample of matched students



Note: Authors' estimate of the equation 2.3. Pooled sample of first to fifth graders. The estimates consider the sample of schools that offered *Acelera* in at least one year between 2010 and 2014.

2.6 Results

Table 2.4 presents the results of the difference-in-differences and leads and lags framework for grade promotion and dropout rates considering the pooled sample of first to fifth-grade students. The DiD approach provides the average treatment effect of *Acelera* for the year the students were allocated in one of the program's classes and also after that (when they returned to regular education).[60] On the other hand, the leads and lags approach makes it possible to disentangle the average impact of the intervention for the year the student received the treatment and for the years after that, allowing us to check if the impacts grow or fade within time (Figure 2.1).

The baseline DiD specification suggests that *Acelera* led to an 18 percentage points (pp) increase in grade promotion of primary education students (column I of Table 2.4). Since the average

[60]The treatment status under the DiD approach is equal to zero before the student joins the intervention, and equal to one in the year the student was allocated into an *Acelera* classroom and also in the years after that.

grade promotion of participants before the intervention was 70%, the 18 pp estimate is equivalent to a jump of 25%. The baseline leads and lags estimate indicates a 10 pp increase in grade promotion rates in the year of participation, equivalent to a 14 pp increase (column II of Table 2.4). The fact that DiD estimates are bigger than the leads and lags suggests that the program increased grade promotion in the year students were allocated into a separated classroom and continued impacting them after the return to regular education.

One of the concerns brought by the baseline specifications is that, although I compare only eligible students, part of them are from schools that do not offer *Acelera* , which are significantly different from the ones that only offer regular education. In this sense, the estimates might be biased if non-observable factors of participant schools are correlated with both the allocation of a set of their students into *Acelera* classes and the dependent variables of the study. To test if this is the case, we run the analysis on a sample that includes in the comparison group only eligible students from schools that offered *Acelera* (Columns III and IV of Table 2.4). I observe that the estimates are similar to the ones presented in columns I and II.[61]

Another identification threat is that I do not observe all the factors that determined the selection of a student into a *Acelera* class. The schools did not include all the students with age-grade distortion in the intervention, creating an overlap in the distribution of the years of age-grade distortion between participants and non-participants (Figure B.1). We explore this by matching students based on some of their characteristics in order to compare the most similar groups, with the difference that some were selected to participate and others not (columns V to VIII of Table 2.4). The estimates are similar, although a bit bigger than the non-matched sample. The differences might suggest that the analysis with the non-matched sample underestimates the impact of the program since the comparison group includes students that are more different than the participants and probably have better educational indicators that lead them not to be included in *Acelera* .

Regarding the immediate impact of *Acelera* on dropout rates, the leads and lags results, although imprecise, indicate that, in the year of the treatment, students are less likely to dropout. This might be associated with the dynamics of *Acelera* classes as students are constantly motivated and also to the school curriculum, which is more adequate to their learning level and makes it

[61] Although the point estimate of leads and lags presented in column II is smaller than the one column IV, it is possible to see that 10.2 pp is included in the confidence interval for the column IV estimates.

easier to keep pace with the classes.

Table 2.4: Impact of *Acelera* on grade promotion and dropout rates, first-fifth grade

Grade promotion								
	No matching				Matching			
	All schools		Acelera schools		All schools		Acelera schools	
	DiD	Leads, lags	DiD	Leads, lags	DiD	Leads, lags	DiD	Leads, lags
	I	II	III	IV	V	VI	VII	VIII
ATT	18.17***	10.20***	17.14***	13.82***	21.59***	14.04***	17.80***	13.84***
	1.22	1.57	1.4	1.88	1.31	1.75	1.57	2.1
	[15.78,20.56]	[7.13,13.28]	[14.39,19.88]	[10.14,17.49]	[19.03,24.16]	[10.61,17.48]	[14.71,20.89]	[9.72,17.95]
Treatment Group								
Mean outcome	69.73	69.73	69.7	69.7	69.76	69.76	69.7	69.7
SD	45.95	45.95	45.96	45.96	45.93	45.93	45.96	45.96
ATT in sd	0.4	0.22	0.37	0.3	0.47	0.31	0.39	0.3
Comparison Group								
Mean outcome	72.78	72.78	70.41	70.41	73.31	73.31	70.44	70.44
Dropout								
	No matching				Matching			
	All schools		Acelera schools		All schools		Acelera schools	
	DiD	Leads, lags	DiD	Leads, lags	DiD	Leads, lags	DiD	Leads, lags
	I	II	III	IV	V	VI	VII	VIII
ATT	0.74*	-0.94	1.10**	-0.6	0.79*	-1.56**	0.89	-1.41*
	0.43	0.58	0.49	0.66	0.47	0.66	0.56	0.79
	[-0.10,1.59]	[-2.07,0.19]	[0.14,2.07]	[-1.89,0.68]	[-0.14,1.72]	[-2.86,-0.26]	[-0.21,1.98]	[-2.95,0.13]
Treatment Group								
Mean outcome	0.99	0.99	0.99	0.99	0.98	0.98	0.99	0.99
SD	9.89	9.89	9.9	9.9	9.87	9.87	9.9	9.9
ATT in sd	0.08	-0.09	0.11	-0.06	0.08	-0.16	0.09	-0.14
Comparison Group								
Mean outcome	1.57	1.57	1.5	1.5	1.77	1.77	1.84	1.84
Obs	85,259	85,259	29,417	29,417	45,653	45,653	24,701	24,701
Num. schools	224	224	217	217	223	223	216	216
Acelera students	1,763	1,763	1,756	1,756	1,770	1,770	1,756	1,756
Students in regular education	18,864	18,864	5,007	5,007	8,698	8,698	3,702	3,702

Notes: ***, **, and * indicate significance at the 1, 5, and 10% critical level. Equations 2.1 and 2.3. The Table does not included students that participated of *Se Liga*. The columns "no matching" include the sample of all eligible students. The columns "matching" include only matched students from treatment and comparison groups. The columns "All schools" include all locally-managed schools in Recife. The columns "*Acelera* schools" include only students that have ever been eligible to treatment in a school that offered *Acelera* .

Table 2.5: Heterogeneity of the impact of *Acelera* on grade promotion and dropout rates, first-fifth grade

	Matching on Acelera schools, leads and lags							
	Grade promotion				Dropout			
ATT	13.84***	14.87***	11.73***	30.99***	-1.41*	-1.25	-2.04	-5.24***
	2.1	2.2	3.41	2.91	0.79	0.85	1.29	1.48
ATT versus gender		-2.66				-0.4		
		1.83				0.84		
ATT versus age dif class			0.78				0.23	
			0.94				0.41	
ATT versus distortion				-7.74***				1.73**
				1.13				0.73
Obs	24,701	24,701	24,701	24,701	24,701	24,701	24,701	24,701
R2	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05
Acelera students	1,756	1,756	1,756	1,756	1,756	1,756	1,756	1,756
Students in regular education	3,702	3,702	3,702	3,702	3,702	3,702	3,702	3,702

Notes: ***, **, and * indicate significance at the 1, 5, and 10% critical level.

To investigate the underlying channels, I propose an additional specification in which we interact the treatment with some of the students' characteristics, such as sex, the difference between their age and the adequate age of the grade they are enrolled in, and the age difference between the youngest and the oldest student of their classroom (Table 2.5). I observe that the program does not to seem to affect boys differently than girls.

Since *Acelera* classes gather students with distinct levels of age-grade distortion, one may wonder whether the students with higher levels of delay could face more challenges during the project implementation. The higher levels of distortion can be associated with lack of motivation and self-esteem problems, as these students have watched their peers change grades, while they were retained. Indeed, the results indicate that the higher the age-distortion, the lower the jump in grade promotion rates due to *Acelera* .

Also, *Acelera* classes are set up with students from different grades, which could raise questions on whether the higher the difference between the youngest and the oldest of the class would impact the program's implementation. I do not find evidence that this is the case.

Table 2.6 presents the results of the difference-in-differences approach for students' proficiency in Portuguese and math. I find evidence that *Acelera* led to an increase in learning levels of 0.05 of a standard deviation. As described in Section 2.4, due to the availability of the exam data, this estimate is for students that joined the intervention in the fourth grade in relation to the ones that, although eligible, did not participate.

At first, the impact of 0.05 of a standard deviation is low when compared to the other *Teaching at the Right Level* interventions, such the *Balsaki Program* in India, with an estimated impact of at least 0.6 sd, the *Switch-on Reading* in England, with 0.24 sd, the *Teacher Community Assistant Initiative* in Ghana, with 0.15 sd, and the *High-Dosage Reading Tutoring* in the United States, with 0.09 sd (Banerjee et al. (2007), Gorard et al. (2017), Duflo et al. (2020), Fryer Jr and Howard-Noveck (2020)). However, I believe that the estimate is a lower bound of the true impact of the intervention since the ultimate goal of *Acelera* is to make students jump up to two grades. Indeed, more than one-third of fourth-grade participants jumped right to six-grade and, therefore, do not have proficiency data available in fifth grade. As it is reasonable to assume that these students are among the best performers, we ended up underestimating the true impact of the intervention.

Table 2.6: Impact of *Acelera* proficiency on students' learning, fourth grade

	Portuguese				Math			
	No matching		Matching		No matching		Matching	
	All schools	Acelera schools	All schools	Acelera schools	All schools	Acelera schools	All schools	Acelera schools
	I	II	III	IV	I	II	III	IV
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
ATT	-0.01	0	0.05**	0.06**	-0.02	-0.01	0.05**	0.06**
se	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02
95% CI	[-0.04,0.01]	[-0.03,0.03]	[0.01,0.10]	[0.01,0.10]	[-0.04,0.01]	[-0.04,0.02]	[0.00,0.09]	[0.01,0.10]
Obs	8604	2652	766	688	7506	2450	776	688
R2	0.19	0.25	0.31	0.33	0.12	0.2	0.24	0.33
Treatment Group	267	267	140	137	243	243	127	137
Acelera students	447.52	447.52	446.44	447.81	455.72	455.72	450.78	447.81
Mean outcome, in %	92.21	92.21	92.47	93.41	89.09	89.09	84.16	93.41
Comparison Group								
Students in regular education	4035	1059	294	207	3510	982	261	207
Mean outcome, in %	464.55	465.22	468.87	470.75	463.64	464.12	471.61	470.75
Num. schools	211	169	106	96	211	164	96	96

Notes: ***, **, and * indicate significance at the 1, 5, and 10% critical level. Equation 2.1. The columns "no matching" include the sample of all eligible students. The columns "matching" include only matched students from treatment and comparison groups. The columns "All schools" include all locally-managed schools in Recife. The columns "Acelera schools" include only students from schools that offered *Acelera* in at least one year between 2010 and 2018.

2.7 Discussion and Conclusion

In the last decades, Brazil has made huge progress in universalizing access to primary education, such that, in 2019, the net enrollment rate of children from 6 to 14 years old reached 99.3%, more than the average observed for developing countries. Nonetheless, more than one out of five children had not yet finished lower secondary education by age 16, the age that they are already supposed to be in high school.[62] Also, almost 40% of fifth-graders did not have an adequate level of proficiency in Portuguese, and the percentage is close to 50% in math.[63] Those lagging behind will struggle in later grades and might never catch up, leading to repetition, dropout and, as a consequence, age-grade distortion. In this context, interventions aimed to adequate the school content to students' level of education, *Teaching at the Right Level*, can be an import tool.

In 2010, Ayrton Senna Institute and the Department of Education of Recife, in the state of Pernambuco, implemented *Acelera* , a program that groups primary education students lagging behind their peers and that are at least one year older than the adequate age for their grade. The students are then allocated to a new class for the whole school year. The intervention aims to increase learning levels, grade promotion, and decrease dropout and age-grade distortion. In this chapter, we employ a difference-in-differences analysis on a rich dataset at the student level to assess the impact of the program from 2010 to 2018.

To estimate the impact of *Acelera* on grade promotion and dropout rates, the data available allows me to follow a panel of first to fifth-graders. I find evidence that the program not only increased grade promotion in the year of participation but also in the years after that. The results show an increase in grade promotion rates of 15 percentage points, a jump of 25% when compared to baseline levels. Also, I find some evidence that treated students are less likely to drop out in the year of the intervention. The results also point out that, the higher the levels of age-grade distortion, the less the students benefit from the intervention, which can be associated with lack of motivation and self-esteem problems, as these students have watched their peers change grades while they were retained.

[62] See the Educational Report of *Todos pela Educação* in this link: https://todospelaeducacao.org.br/wordpress/wp-content/uploads/2020/10/Anuario-Brasileiro-Educacao-Basica-2020-web-outubro.pdf

[63] See the Educational Report of *Todos pela Educação* in this link: https://todospelaeducacao.org.br/wordpress/wp-content/uploads/2021/09/relatorio-de-aprendizagem.pdf

The results suggest that *Acelera* partially achieved its ultimate goal, which is enabling students to jump up to two grades. This was the case for 63%, 37% and 28% of third, fourth, and fifth-graders, respectively. Nonetheless, one may wonder whether the students were approved because they actually achieved an adequate level of proficiency that allowed them to jump to the next grade, or as a simple consequence of the program participation. I then investigate the effects of *Acelera* on students' proficiency in Portuguese and math and, indeed, the program is estimated to have increased students' learning levels by 0.05 of a standard deviation.

Although the impact of *Acelera* on students' proficiency in reading and math seems low when compared to other *Teaching at the Right Level* interventions, such as 0.6 sd in India, 0.24 sd in England, 0.15 sd in Ghana, and 0.09 sd in the United States, I believe that this estimate is a lower bound of the true impact of the program (Banerjee et al. (2007), Gorard et al. (2017), Duflo et al. (2020), Fryer Jr and Howard-Noveck (2020)). *Acelera* allows students to jump up to two grades, which was the case of one-third of fourth-grade participants, the ones who went right to sixth grade and ended up not doing the standardized proficiency assessment while in fifth grade (when the test is applied). As it is reasonable to assume that these students are among the best performers, we ended up underestimating the true impact of the intervention.

Overall, the interventions aimed to adequate school content with children's level of education seem an important tool to increase grade-promotion and also enable increase in proficiency, especially after a pandemic outbreak.

3 Estimating the efficiency of public primary education expenditures in Brazil

3.1 Introduction

Education has a crucial role in economic activity across the world. The more the cognitive skills of a countries' workforce, the higher its economic growth and per capita income. Those cognitive skills are determined by family background, individual abilities, and formal schooling, the one the policymakers emphasize as they are the most directly affected by public policies (Hanushek (2006)).

The conventional wisdom states that public schools require additional resources to increase students' performance. However, the available evidence points out that, overall, schools fail to use their resources efficiently, suggesting that there is room to increase students' learning levels without additional expenditures. To estimate how efficiently the Brazilian municipalities use their resources, I employ a Data Envelopment Analysis to investigate the relationship between per-pupil expenditure and students' proficiency in reading and math, as well as grade-promotion.

The output under evaluation is the last data available for the most important education indicator in the country, the 2019 Education Development Index (IDEB). Considering that the IDEB is a function of the investment made in children since their first grade, my model has five inputs of per-pupil expenditures, one for each year of primary education. As socioeconomic background plays a crucial role in students' achievement, I use the percentage of mothers that finished high school as a non-discretionary input, that is, one that the municipality cannot change, unless in the long run. In addition to that, as the municipalities in Brazil have distinct infrastructure and physical and human capital, I define five clusters of them based on their population size. By doing that, I assume that they operate under different production functions. I then estimate a production frontier for each one of these groups, the group-frontier, and one frontier for the whole sample, the meta-frontier.

Overall, the group-frontier results indicate that the Brazilian municipalities efficiently use between 68% to 81% of their educational resources. This suggests that if the local authorities

could reach the production frontier, there would be a fiscal space of at least 87 billion BRL. An amount that could be allocated in interventions to increase students' performance in a post-pandemic context where they are so much needed. To have an idea of what 87 billion BRL represents in Brazil, it is more than twice the annual 2022 annual 2022 *Bolsa Família* budget, the most import conditional cash transfer in the country that reaches more than 10 million families.

According to the Education at a Glance (2021), the expenditure per primary education student in Brazil is approximately two and a half times lower than the OECD average. In that sense, it is important to point out that municipalities classified as efficient in my analysis, or the remaining ones once they reach the production frontier, might require additional resources. It is possible that their current level of expenditures is not the optimal one required for students to achieve an adequate level of proficiency. In this case, local authorities would need to increase per-pupil expenditure and ideally expand their scale of operation along the efficient frontier.

The contributions of the chapter are twofold. First, to my knowledge, this is the first analysis that explores the efficiency of public primary education expenditures in Brazilian municipalities using the last IDEB available (2019) under a Data Envelopment Analysis. This, combined with a group-frontier analysis, the inclusion of a non-discretionary input, and a super-efficiency approach to detect outliers are innovations in the literature. Second, it provides an estimate of the fiscal space that would be achieved if municipalities reach the production frontier. Resources that could be employed in education interventions in a country that was severely hit by the Covid-19 outbreak and that faced a significant decrease in students' performance since most schools were closed for at least one year.

Apart from this introduction, this chapter is organized as follows: Section 3.2 presents a literature review. Section 3.3 introduces the data available to perform the analysis. Section 3.4 discuss the empirical strategy. Section 3.5 presents the main findings. I then conclude with a discussion and policy implications in Section 3.6.

3.2 Related Literature

The education production function is used to investigate the relationship between school inputs, such as per-pupil expenditure, and students' outputs, such as academic achievement (Pigott et al. (2012)). Coleman (1968) is the vanguard in that regard, setting the standards adopted since them. In the sixties, the author analyzed survey data from 600,000 students, 60,000 teachers, and 4,000 public schools in the United States, aiming to understand what were the determinants of students' capacity to learn. He then explored the influence of schools' amenities, students' family background and peers, per-pupil expenditure, and teachers' knowledge and practices in the classroom. The author concluded that family background was the main determinant of how well children learn, instead of schools' physical infrastructure or funding. His analysis was followed by a spate of studies that gathered new data to explore the relationship between schools' inputs and outputs.

Hanushek (1981, 1986, 1996) analyzed hundreds of studies to understand the relationship between students' achievement and schools' expenditures, mostly determined by pupil-teacher ratios, and teachers' salaries which in turn are largely explained by their education and experience. The author concluded additional dollars on traditional policies, such as reducing class sizes or hiring more qualified teachers, are unlikely to be matched by a significant increase in student achievement in the USA.

The weak association between increased per-pupil expenditure and students' performance raises questions on how efficiently public education expenditures are made, leading to extensive literature aimed to measure it. The most common methodologies employed for this task are the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). On the one hand, the main benefit of the DEA is that it is non-parametric, as there is no need to specify a functional form relating inputs to outputs. On the other hand, one needs to specify a functional form under SFA, however, the model allows the differentiation of statistical noise from inefficiency (Ruggiero (2007)).

Schools, municipalities, or countries are the decision-making units (DMUs) in charge of the education process. In DEA and SFA, a production frontier is empirically estimated by comparing input-output combinations of several DMUs. The production units in the frontier

are the ones that achieve the maximum output level given the inputs being used and the technology available. They provide a benchmark from which other DMUs in the sample are compared too, allowing the calculation of an inefficiency measure. In this sense, the drawn frontier depends on the sample chosen and does not necessarily mean that there is no room for improvement. Nonetheless, the more DMUs included in the sample, the closer the estimated frontier is to the true one (Mattos and Terra (2015a)).

Under a technical efficiency framework, the most common inputs are pupil-teacher ratio and schools' amenities and schools' hours. Still, DMUs can be technically efficient but use inputs that might be expensive. In this context, a cost-efficiency analysis arises, adopting per-pupil expenditure as the main input (Afonso and Aubyn (2005)). Also, non-discretionary inputs, such as socioeconomic background, are commonly used as they play a crucial role on students' achievement, but cannot be changed, unless in the long run. On the output side, the most common ones are students' performance in reading and math, school dropout, rates of continuation to further schooling, and attendance patterns (Hanushek (1981)).

Sutherland et al. (2007) employed a Data Envelopment Analysis to investigate the efficiency of the OECD countries with regard to 15-year-olds performance in reading, math, and sciences on the 2003 Programme for International Student Assessment (PISA). At the school level, the authors conducted a technical efficiency analysis in which the inputs are teaching staff and the number of computers per 100 students. According to their estimates, on the one hand, schools could save up to one-third of their resources, and still achieve the same PISA if they move towards the efficient frontier. On the other hand, while holding per-pupil expenditure constant, schools could boost their PISA by up to one-fifth if they reach the frontier. Also, a cost-efficiency analysis is performed using country-level data with per-pupil expenditure as input. The authors estimated potential financial savings of almost 20%. Students' socioeconomic background is included as a non-discretionary input in all the analyses.

Afonso and Aubyn (2005) also employed a DEA on the OECD countries using the 2000 PISA results. Their study differs from Sutherland et al. (2007) as the inputs are total intended instruction time in hours per year and pupil-teacher ratio. Their results are more conservative and showed scope for savings of 14% of a boost in performance of 7%. Herrera and Pang (2005) using data for 140 countries from 1996 to 2002 employed a cost-efficiency DEA, in which the

input is the aggregated public expenditures. The authors used several educational and health outcomes, such as primary and secondary enrollment, literacy rates, average years of schooling, graduation rates, and learning scores, life expectancy at birth, and immunization rates. Their estimates showed the potential to increase outputs by 10% to 30% if the countries used their resources efficiently.

OECD countries are significantly different than Brazil. According to the Education at a Glance (2021), the USD 3,748 expenditure per primary education student in Brazil is approximately two and a half times lower than the USD 10,101 OECD average, a fact that is mainly explained by the gap in teachers' annual salaries (USD 25,366 versus USD 45,687).[64] Even so, Menezes-Filho et al. (2009) also found evidence of a weak association between per-pupil expenditure on 2005 students' performance in reading and math. Their study was followed by several efficiency analyses that indicated that overall Brazilian schools fail to use resources efficiently.

Rocha et al. (2013) assessed the cost-efficiency of the Brazilian municipalities using a DEA in which the output is the Education Development Index, an indicator that combines students' grade promotion rates and proficiency in reading and math. They assumed that municipalities have different technologies depending on their population size and, therefore, do not have the same education production function. The authors then estimated five production frontiers using per-pupil expenditure and the education of students' mothers as the discretionary and non-discretionary inputs, respectively. The estimates showed potential financial savings of 40% if municipalities used their resources efficiently.

Araújo Junior et al. (2019) estimated the technical efficiency of the Brazilian Northeastern municipalities and whether there was an improvement between 2007 and 2013. Similar to Rocha et al. (2013), the authors defined five clusters of municipalities, based on population size, GDP per capita and quality of life, and economic development. They found evidence that the efficiency improved over the years but still more than half of the municipalities could boost their proficiency by at least 25% without increasing per-pupil expenditure if they moved towards the efficient frontier. Also, the analysis indicated that smaller municipalities tend to be less efficient, similar to the results of Rocha et al. (2013) and de Sousa et al. (2005).

[64] See the country report for Brazil in this link: https://www.oecd-ilibrary.org/sites/d8d547f5-en/index.html?itemId=/content/component/d8d547f5-enchapter-d12020e23927

Melo Castro et al. (2017) employed a stochastic frontier approach to estimate an education production function for the Brazilian municipalities, in which the output is the percentage of students with an adequate level of proficiency in reading and math. The authors estimated the prices of the labor force, capital, and other administrative expenses based on the total expenditure declared by the municipality in each of these categories and what these amounts can afford in terms of schools' staff, infrastructure and size. The inputs of their model are school daily hours, percentage of teachers with undergrad, students' household infrastructure and parents' support, and municipalities' illiterate rates, inequality levels, and urbanization rates. The estimates showed a cost-inefficiency of almost 15% and that higher efficiency levels could be achieved if schools increase the length of the school day and at the same time increase the pupil-teacher ratio.

3.3 Data

In Brazil, the 26 states, the Federal district, and the 5,570 municipalities share the responsibilities for the provision of public education. The municipal governments should give priority to early childhood and primary (first to fifth grade) and lower secondary education (sixth to ninth grade), and the state authorities to primary, lower, and upper secondary education. According to the 2019 Census of Education, 5,555 municipalities have at least one primary education school managed by the respective local authority, and 2,154 municipalities have primary schools managed by the state governments. With this organization, municipal governments have almost 85% of public primary education students enrolled in schools under their management.

Since 1995, all private and public K-12 schools participate in the annual Census of Education, implemented by the National Institute of Educational Studies and Research (INEP), a research agency under the Brazilian Ministry of Education.[65] The Census collects information on school facilities, teachers, and students. The schools have to report several variables at the student level, such as the gender, color of the skin, age, any physical disabilities or mental illness, grade level, instruction time per day, and status of the student at the end of the school year (approved, repeated or dropped out). The INEP then uses this information to disclose

[65] INEP stands for *Instituto Nacional de Estudos e Pesquisas Educacionais*.

educational indicators at school, municipality, state, and national levels. All the data can be shown by type of school: private, local, state, and federal-managed schools. Therefore, I observe for each municipality, for example, dropout rates by schools' level of administration.

Every two years, the INEP applies a proficiency assessment, the *Prova Brasil*, to fifth graders of public and private schools, a test that is within the scope of the Education Assessment System (SAEB).[66] For fifth-graders, the exam has a scale ranging from 0 to 325, and a math scale ranging from 0 to 350 (SAEB scale). Children also answer a socioeconomic questionnaire with information on their household infrastructure; parents' educational attainment; incentives from the family to pursue an education; time watching TV, on the internet, reading books, and doing homework; if they already dropped out or repeated a grade; and if they did kindergarten. The socioeconomic information can also be aggregated at the municipality level by schools' level of administration, for example, the percentage of fifth-graders whose mothers finished high school in locally-managed schools.

Data from the Census of Education and *Prova Brasil* are used to calculate the National Education Development Index (IDEB), the most important educational indicator in Brazil, that monitors students' grade promotion and learning levels.[67] To compute the index, the students' Portuguese and math performance is transformed into a standardized proficiency ranging from 0 to 10. This score is then multiplied by the students' grade promotion rates to obtain the IDEB at school, municipal, state, and national levels. For primary education, the index is the product of the standardized performance of fifth-graders and the average grade promotion from first to fifth grades. The index scale ranges from 0 to 10. Central and local governments use IDEB to monitor the improvement in the quality of public and private education in Brazil and compare schools' performance within and between municipalities, and also between private, local, and state-managed networks.

The Information System on Expenditures in Education (SIOPE) is released by the National Fund for Education Development (FNDE), an agency under the Brazilian Ministry of Education.[68] Municipalities and states have to report to the SIOPE their total expenditures

[66] Schools with at least 20 students enrolled. Proficiency tests are also applied to students and ninth grade and in the last grade of high school.SAEB stands for *Sistema de Avaliação da Educação Básica.*

[67] IDEB stands for *Índice de Desenvolvimento da Educação Básica.*

[68] SIOPE stands for *Sistema de Informações sobre Orçamentos Públicos em Educação.* FNDE stands for *Fundo Nacional de Desenvolvimento da Educação Básica.*

in education, such as teachers' salaries, school infrastructure, textbooks, and an estimate of per-pupil expenditure. The information needs to be reported by the level of education: i) pre-school and kindergarten, ii) primary and lower secondary education (first to ninth grade), and iii) upper secondary education (high school). The SIOPE then discloses the data at the state level for the 26 state governments and the Federal District and at the municipal level for the 5,570 local authorities. Hence, it is possible to observe per-pupil expenditure across all state and locally-managed networks in the whole country.

To estimate the efficiency of public primary education expenditures in Brazil, I restrict the sample to schools managed by the municipal governments, as almost all municipalities provide first to fifth grades and are in charge of approximately 85% of enrollment in this level of education. The outcome is the 2019 IDEB, which I consider that it is a function of the per-pupil expenditure and students' socioeconomic background. As the performance of fifth graders is influenced by the investments made since they joined the school, I work with the per-pupil expenditure in 2019, when students were in fifth grade, in 2018 (fourth grade), in 2017 (third grade), in 2016 (second grade), and 2015 (first grade).[69] To account for students' background once it plays an important role in their performance, I use as a non-discretionary input the percentage of students' mothers that finished high school.

Brazil is a continental country where the cost of living significantly changes from north to south and in metropolitan, urban and rural areas. To account that the same amount of per-pupil expenditure does not mean the same depending on the region, I adjust this variable by an estimate of the cost of living across the whole country (Table C.1). If the municipality belongs to a metropolitan area, I multiply the per-pupil expenditure by the respective cost of living. For the remaining municipalities, I first calculate the percentage of enrollments in urban and rural areas and use them as a weight when multiplying the per-pupil expenditure by the respective cost of living in these areas.[70]

On the one hand, bigger municipalities might face more challenges to manage their school systems, which are likely to be more complex as they have more schools under their management. On the other hand, some small municipalities might have less qualified personnel in charge of their educational policies and are more likely to be captured by local elites. According

[69] This assumption is valid for students that did not repeat any grade.
[70] I exclude the municipalities that are in the bottom 1% of the per-pupil expenditure distribution.

to 2019 information disclosed by the Brazilian Institute of Geography and Research (IBGE), municipalities have an average population size of 37 thousand. Around one-fourth of them had up to 5 thousand inhabitants, and only 1% have more than 400 thousand.[71] To account for the fact that these governments have different education production functions, I work with five groups, following the IBGE definition when separating municipalities by population size. The first group is the ones that have up to 5 thousand inhabitants (22.3%). The second, between five and fifty thousand (65.6%). The third, between fifth and 100 thousand (6.3%). The fourth, between 100 and 500 thousand (5%). The fifth, more than 500 thousand (0.8%).

The descriptive statistics for performance, expenditure and students' socioeconomic background are shown in Table C.2. To perform the efficiency analysis, I work on a sample of municipalities in which all the variables are available, reducing the sample size from 5,570 to 4,682 municipalities (Table C.3).

3.4 Empirical Strategy

Data Envelopment Analysis (DEA) is a non-parametric methodology for efficiency analysis first introduced by Charnes et al. (1978). The idea is to assess the relative efficiency of a set of Decision Making Units (DMUs), which are the production units under evaluation, such as schools, hospitals, municipalities, or countries. A linear programming model is employed to compare the inputs used by the DMUs, such as the per-pupil expenditure, with the outputs achieved, in this case, students' proficiency.

The DEA framework can easily accommodate multiple outputs and inputs and it is not necessary to specify any functional form (Sutherland et al. (2007)). Also, the methodology assumes that linear combinations of observed input-output bundles are feasible (Herrera and Pang (2005)). Considering the technology available, the output-oriented efficiency measures the difference between what the DMU achieves and what would be possible to achieve if it operates in the production frontier, that is, the shortfall of outputs for a given level of inputs. The input-oriented efficiency measures the difference between the inputs being used and the minimum amount that would still be enough to reach a certain level of output if the DMU operates in

[71] IBGE stands for *Instituto Brasileiro de Geografia e Estatística.*

the frontier, that is, the excess of input consumption (Mattos and Terra (2015a)).

DEA specifications can have constant returns to scale (CRS), which assumes proportionality between outputs and inputs, or variable returns to scale (VRS), a relaxation of the previous assumption as it allows that the increase in the inputs does not need to be followed by a proportional increase in outcomes for the DMU to be considered efficient. The VRS is more adequate for this analysis since, given a specific increase of one of the outputs, it is more feasible for a low-performer DMU to increase its education outcomes compared to a unit that already has a high performance.

Consider a VRS DEA with n DMUs in the reference set, i inputs, and s outputs. An input-oriented approach with variable returns to scale consists of solving, for each decision-making unit k under evaluation, the following problem:

$$\begin{aligned} &\text{Min}\,\theta_k, \text{ subject to:} \\ &\sum_{j=1}^{n} \alpha_j x_{ij} \leq \theta_k x_{ik}, \; \forall \; i \in 1, 2, .., m \\ &\sum_{j=1}^{n} \alpha_j y_{rj} \geq y_{rk}, \;\; \forall \; r \in 1, 2, .., s \\ &\sum_{j=1}^{n} \alpha_j = 1, \; \alpha_j > 0 \end{aligned} \tag{3.1}$$

In which j is the subscript for all the DMUs in the sample and assumes values from 1 to n. x_{ij} and x_{ik} represent the input i being used by the DMU j and k, respectively; and y_{rj} and y_{rk} represent the output r reached by DMU j and k, respectively. Intuitively, the model performs n minimization problems, one for each DMU, with $m+s+1$ restrictions to check whether there is a linear combination of inputs in the reference set, weighted by α_j, that is inferior to the one being used by the DMU k and that still produces more or the same amount of outputs. θ_k represents the share of inputs being used efficiently by DMU k, the input-oriented efficiency score.

The DMU k is considered efficient if there is no combination of inputs in the reference set of DMUs that uses fewer inputs and still produces more outputs than it. In this case, θ_k assumes

a value of 1. Therefore, it is possible to observe that, by construction, at least one DMU in the sample is classified as efficient and provides a benchmark to which others are compared. For inefficient DMUs, there is a linear combination of inputs in the reference set that is inferior to the one being used by it but that produces the same or more outputs. In this case, $\theta_k < 1$, and $1 - \theta_k$ represent the proportion of inputs that should be reduced for the DMU k to become efficient. This model has a strong assumption as it assumes that all the inputs can decrease. For a more accurate analysis, one can specify non-discretionary inputs, the ones that, at least in the short run, cannot be changed.

The equation 3.2 shows the minimization problem under an output-oriented approach. In this case, if there is not a linear combination of DMUs in the reference set that employs fewer inputs than unit k and produces more outputs, θ_k assumes value 1. Otherwise, $\theta_k < 1$, and $\frac{1}{\theta_k}$ is the proportional expansion of outputs needed for the DMU k reach the frontier. Hence, θ_k is the output-oriented efficiency score.

$$
\begin{aligned}
&\text{Min}\, \theta_k, \text{ subject to:} \\
&\sum_{j=1}^{n} \alpha_j x_{ij} \leq x_{ik}, \forall\ i \in 1, 2, .., m \\
&\sum_{j=1}^{n} \alpha_j y_{rj} \geq \frac{y_{rk}}{\theta_k}, \ \ \forall\ r \in 1, 2, .., s \\
&\sum_{j=1}^{n} \alpha_j = 1,\ \alpha_j > 0
\end{aligned}
\tag{3.2}
$$

The DEA constructs a production frontier containing all the DMUs for which $\theta = 1$. They provide a benchmark measure for each inefficient unit and show a linear combination of inputs that represents the efficient amount that the DMU under evaluation needs to employ to emulate the ones in the frontier and achieve $\theta = 1$.

However, this approach has one caveat when it comes to the presence of outliers in the sample, making us overestimate the inefficient of the other DMUs in the reference set. To deal with this, I run a super-efficiency (SE) model to check whether the DMUs that achieved $\theta = 1$ in the first minimization problem are actually outliers instead of good examples that other production

units could emulate. Under this approach, each one of these DMUs is excluded from the sample, one at a time, and a new minimization is performed with the remaining observations. For an efficient DMU k identified in the first minimization problem, the input-oriented VRS-SE model consists in solving:

$$\begin{aligned} &\text{Min}\, \theta_k, \text{ subject to:} \\ &\sum_{\substack{j=1 \\ j\neq k}}^{n} \alpha_j x_{ij} \leq \theta_k x_{ik}, \; \forall \; i \in 1, 2, .., m \\ &\sum_{\substack{j=1 \\ j\neq k}}^{n} \alpha_j y_{rj} \geq y_{rk}, \;\; \forall \; r \in 1, 2, .., s \\ &\sum_{\substack{j=1 \\ j\neq k}}^{n} \alpha_j = 1, \; \alpha_j > 0 \end{aligned} \tag{3.3}$$

Another very important assumption of the DEA is that the DMUs in the reference set are similar to each other, share the same production frontier, and have comparable technologies. These are strong assumptions given that the production units might have distinct infrastructure and physical and human capital (Boueri (2015)). To overcome this threat, I assume that the DMUs operate under different production functions by separating them into groups that are somehow comparable to each other and running a DEA for each of them. I then define five clusters of municipalities based on population-size as described in Section 3.3.

First, for each one of the five groups, I run a DEA model that measures the efficiency of the DMU k relative to the common frontier of its group, the *Group-Frontier*. The comparison of the efficiency scores between clusters is not valid as it is assumed that the groups have different production environments. Second, in a hypothetical scenario in which all the municipalities have the same technology, I run a DEA for the five groups together, the *Meta-Frontier*. Therefore, the distance between the group and the meta-frontiers is an estimated measure of the technological gap existent between the DMUs (Wongchai et al. (2012)). In this sense, the DMUs in the group frontier would move to the meta frontier if they could increase the productivity of the inputs being used (Mattos and Terra (2015b)).

To assess the efficiency of public primary education expenditures in Brazil, the 2019 primary education IDEB is the only output of the model. The index combines students' proficiency with grade promotion, representing the main variables used in the educational production process (Hanushek (1996)). As Hanushek (1986) documents, past investments made on children influence their current level of achievement, I work with five discretionary inputs: the per-pupil expenditure made in 2019, 2018, 2017, 2016, and 2015, all expressed in 2020 BRL. It is also well documented that students' background significantly affects their performance. In this sense, municipalities can have the same per-pupil expenditure, but different performance and a simple comparison would not be adequate, as they might have to deal with distinct socioeconomic contexts. It is notably easier for a municipality whose students' mothers have higher education achievement to reach higher Portuguese and math proficiency for a given level of expenditure. For that reason, I use the percentage of students' mothers that finished high school as a non-discretionary input (Coleman (1968), Hanushek (2006)).

3.5 Results

Table 3.1 shows the results of the input-oriented approach. The baseline estimate shows that 268 municipalities are in the group-frontier ($\theta = 1$), which represents around 5.5% of the DMUs in the sample (Table C.4). These are the municipalities that have an efficient combination of per-pupil expenditure achieving the maximum possible performance given their current level of expenditures when compared to other local authorities of their group sample. More than two-thirds are in the north and northeast of Brazil (Table C.4).

The efficient scores indicate that, on average, municipalities efficiently use between 68% and 81% of public primary education resources, depending on their size. The results suggest that if the local authorities could emulate the educational policies adopted by the frontier municipalities, that are somehow similar to them, there would be a fiscal space of at least 87 billion BRL. An amount that could be allocated in interventions to increase students' performance in a post-pandemic context where they are so much needed. To have an idea of what 87 billion BRL represents in Brazil, it is more than twice the annual 2022 *Bolsa Família* budget, the most import conditional cash transfer in the country that reaches more than 10 million families.

Except for municipalities that have between 5 and 50 thousand inhabitants, all the other clusters have group-frontier scores significantly higher than the meta-frontier one. This indicates that municipalities with up to 5 thousand inhabitants and those with more than 50 thousand have an educational production function assumed to have a technological gap when compared with municipalities that have between 5 and 50 thousand inhabitants, the ones that mostly made up the meta-frontier. On the one hand, bigger municipalities might face more challenges to manage their school systems, which are likely to be more complex as they have more schools under their management. On the other hand, some small municipalities might have less qualified personnel in charge of their educational policies and are more likely to be captured by local elites.

I check the robustness of the baseline specification by running three super-efficiency models as described in Section 3.4. I exclude from the analysis the DMUs that according to the super-efficiency model would have to increase their inputs by 30%, 20% or 10% in order to achieve an efficient score of 1 when compared to the other DMUs in the sample, which indicates that they are actually outliers instead of good examples that other production units could emulate. These models are the thresholds 1.3, 1.2, and 1.1, the Columns II, III, and IV of Table 3.1. It is possible to see that the number of benchmark DMUs and potential savings are very robust across all specifications tested.

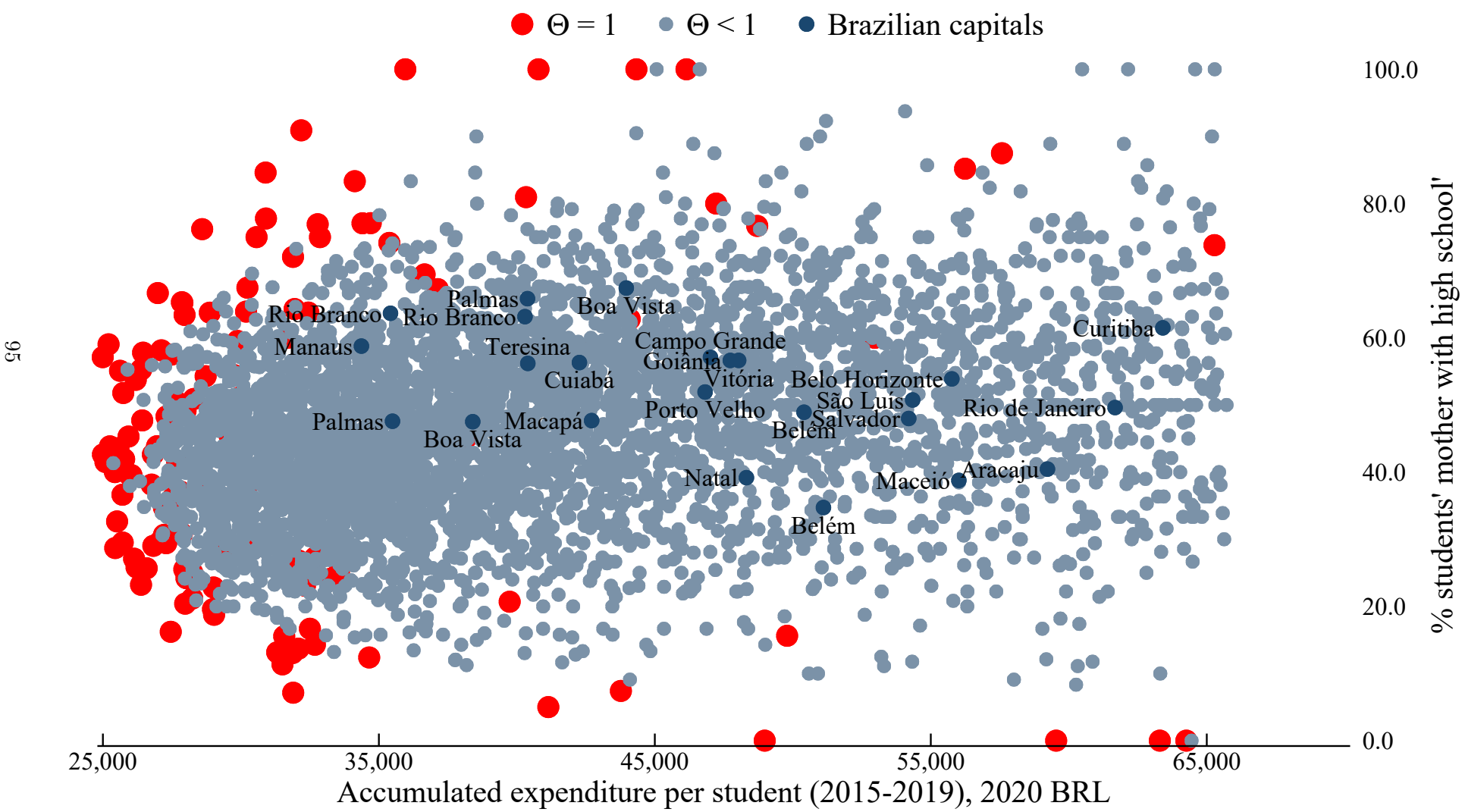
Table 3.1: DEA input-oriented results, 2019

	Group Frontier				Meta Frontier			
	Baseline	Robustness				Robustness		
	Without exclusions	Excluding outliers Thresholds			Without exclusions	Excluding outliers Thresholds		
		1.3	1.2	1.1		1.3	1.2	1.1
	I	II	III	IV	I	II	III	IV
Number of benchmarks								
Up to 5k	54	69	57	71	14	10	14	6
Between 5k and 50k	119	121	112	137	111	113	105	129
Between 50k and 100k	51	52	48	59	10	9	7	3
Between 100k and 500 k	32	35	25	36	12	10	8	5
More than 500k	12	10	10	10	1	0	0	0
Total, Brazil	268	287	252	313	148	142	134	143
Input-oriented efficiency scores								
Up to 5k	0.68	0.70	0.69	0.72	0.59	0.59	0.60	0.60
Between 5k and 50k	0.73	0.73	0.75	0.74	0.72	0.73	0.75	0.74
Between 50k and 100k	0.81	0.81	0.82	0.83	0.73	0.73	0.75	0.74
Between 100k and 500 k	0.78	0.79	0.79	0.80	0.71	0.71	0.73	0.72
More than 500k	0.77	0.80	0.77	0.81	0.59	0.57	0.60	0.55
Total, Brazil					0.70	0.70	0.71	0.71
Potential fiscal space, in billion 2020 BRL								
Up to 5k	3.48	3.25	3.39	3.06	4.54	4.51	4.33	4.35
Between 5k and 50k	34.21	34.14	30.28	32.92	34.62	34.48	30.56	33.12
Between 50k and 100k	9.30	9.03	8.21	7.72	12.78	12.70	11.26	12.09
Between 100k and 500 k	23.29	22.15	21.49	20.44	29.86	29.65	27.15	28.28
More than 500k	31.53	26.69	31.36	23.51	48.15	47.60	45.55	46.22
Total, Brazil	101.81	95.25	94.73	87.65	129.94	128.94	118.85	124.06

Source: Authors' estimate based on 2019 *Prova Brasil*/INEP, and 2015-2019 SIOPE. The columns without exclusions show the number of benchmark municipalities before the exclusion of outliers in terms of efficiency scores achieved by their input-output combinations. The super-efficiency columns indicate the number of benchmark DMUs in the models that exclude outliers. The thresholds used are 1.3, 1.2, and 1.1. The group-frontier does not have efficient scores at national level because the frontiers of each group of municipalities are not comparable. See Section 3.4.

Figure 3.1 shows the distribution of the accumulated expenditure per primary education student, from their first to fifth grade, and the percentage of students' mothers that finished high school. As expected, the municipalities that reach the frontier ($\theta_k = 1$) are the ones that, given more favorable family background, are able to achieve high performance even with low levels of expenditure. Also, municipalities, where students have a less favorable background, can also be efficient even though they have higher per-pupil expenditure.

Figure 3.1: Distribution of per-pupil expenditure and socioeconomic background (2019)



Note: Authors' estimate based on 2019 *Prova Brasil*/INEP, and 2015-2019 SIOPE. Baseline specification of the input-oriented approach. The accumulated per-pupil expenditure is the sum of per-pupil expenditure from 2015 to 2019.

A very interesting result of the DEA is being able to identify the municipalities used as benchmarks by the ones that did not reach the production frontier, as well as the weight attributed to each one of them. This can contribute to the dialogue between municipal governments to share policy interventions aimed to increase students' proficiency.

Table 3.2 shows the results of the output-oriented approach. Given the current per-pupil expenditure, this model estimates what would be the potential performance of the students if municipalities were more efficient in the allocation of public resources. The estimates indicate that if the municipalities operated in the frontier, the national primary education IDEB could potentially reach 8, an increase of more than 40% when compared to 5.7 achieved by the students in 2019.

Table 3.2: DEA output-oriented results, 2019

	Group Frontier				Meta Frontier			
	Baseline	Robustness				Robustness		
	Without exclusions	Excluding outliers Thresholds			Without exclusions	Excluding outliers Thresholds		
		1.3	1.2	1.1		1.3	1.2	1.1
	I	II	III	IV	I	II	III	IV
Number of benchmarks								
Up to 5k	54	62	67	71	14	17	7	6
Between 5k and 50k	119	112	132	137	111	106	124	129
Between 50k and 100k	51	48	52	59	10	7	10	3
Between 100k and 500 k	32	38	35	36	12	7	10	5
More than 500k	12	10	10	10	1	0	0	0
Total, Brazil	268	270	296	313	148	137	151	143
Output-oriented efficiency scores								
Up to 5k	0.77	0.78	0.80	0.80	0.69	0.69	0.68	0.68
Between 5k and 50k	0.68	0.69	0.69	0.69	0.68	0.69	0.69	0.69
Between 50k and 100k	0.80	0.80	0.80	0.81	0.69	0.70	0.69	0.69
Between 100k and 500 k	0.83	0.89	0.83	0.83	0.71	0.72	0.71	0.71
More than 500k	0.89	0.89	0.90	0.89	0.67	0.66	0.66	0.65
Total, Brazil					0.68	0.69	0.69	0.69
Potential IDEB								
Up to 5k	7.73	7.65	7.48	7.43	8.71	8.65	8.72	8.72
Between 5k and 50k	8.31	8.28	8.28	8.22	8.36	8.29	8.31	8.26
Between 50k and 100k	7.36	7.36	7.33	7.26	8.38	8.35	8.34	8.38
Between 100k and 500 k	7.28	6.77	7.24	7.26	8.45	8.45	8.43	8.44
More than 500k	6.46	6.46	6.45	6.48	8.71	8.79	8.83	8.90
Total, Brazil	8.06	8.00	7.99	7.93	8.44	8.38	8.41	8.37

Source: Authors' estimate based on 2019 *Prova Brasil*/INEP, and 2015-2019 SIOPE. The columns without exclusions show the number of benchmark municipalities before the exclusion of outliers in terms of efficiency scores achieved by their input-output combinations. The super-efficiency columns indicate the number of benchmark DMUs in the models that exclude outliers. The thresholds used are 1.3, 1.2, and 1.1. The group-frontier does not have efficient scores at national level because the frontiers of each group of municipalities are not comparable. See Section 3.4.

3.6 Discussion and Conclusion

In this chapter, I employ a Data Envelopment Analysis to investigate the efficiency of public primary education expenditures in Brazil. The output of the model is the last data available for the most important education indicator in the country, the 2019 Education Development Index (IDEB). The discretionary inputs are per-pupil expenditures from children's first to fifth grade and the percentage of mothers that finished high school as non-discretionary. I define five groups of municipalities according to the population size and estimate a production frontier for each one of these groups, the group-frontiers, and one frontier for the whole sample, the meta-frontier.

The meta-frontier analysis assumes that there is no difference in the five groups of local authorities such that it would be possible for a municipality to emulate the best practices of another one that does not belong to the same group. According to this perspective, municipalities with up to five thousand inhabitants (22.3% of the sample) and the ones with more than five hundred thousand (0.8%) are the less efficient ones, using less than two-thirds of their resources efficiently.

Nonetheless, my favorite specification assumes that municipalities have distinct production functions and it is not straightforward to emulate the best practices of another one that does not belong to the same group. Indeed, when compared only to decision-making units from the same group, the municipalities with up to five thousand inhabitants and those with more than five hundred thousand have significantly higher efficiency scores. In this sense, the comparison between the group and meta-frontiers shows that there is a technology gap between the local authorities. On the one hand, bigger municipalities might face more challenges to manage their school systems, which are likely to be more complex as they have more schools under their management. On the other hand, some small municipalities might have less qualified personnel in charge of their educational policies and are more likely to be captured by local elites.

Overall, the group-frontier results indicate that the Brazilian municipalities efficiently use between 68% and 81% of their educational resources. This suggests that if the local authorities could reach the production frontier, there would be a fiscal space of at least 87

billion BRL. An amount that could be allocated in interventions to increase students' performance in a post-pandemic context where they are so much needed. To have an idea of what 87 billion BRL represents in Brazil, it is more than twice the annual 2022 *Bolsa Família* budget, the most import conditional cash transfer in the country that reaches more than 10 million families.

Malmquist Productivity Index decomposes into a a technical efficiency change index and a technical change index.

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A Appendix to Chapter 1

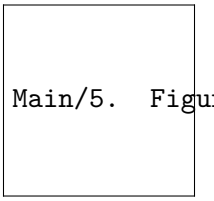
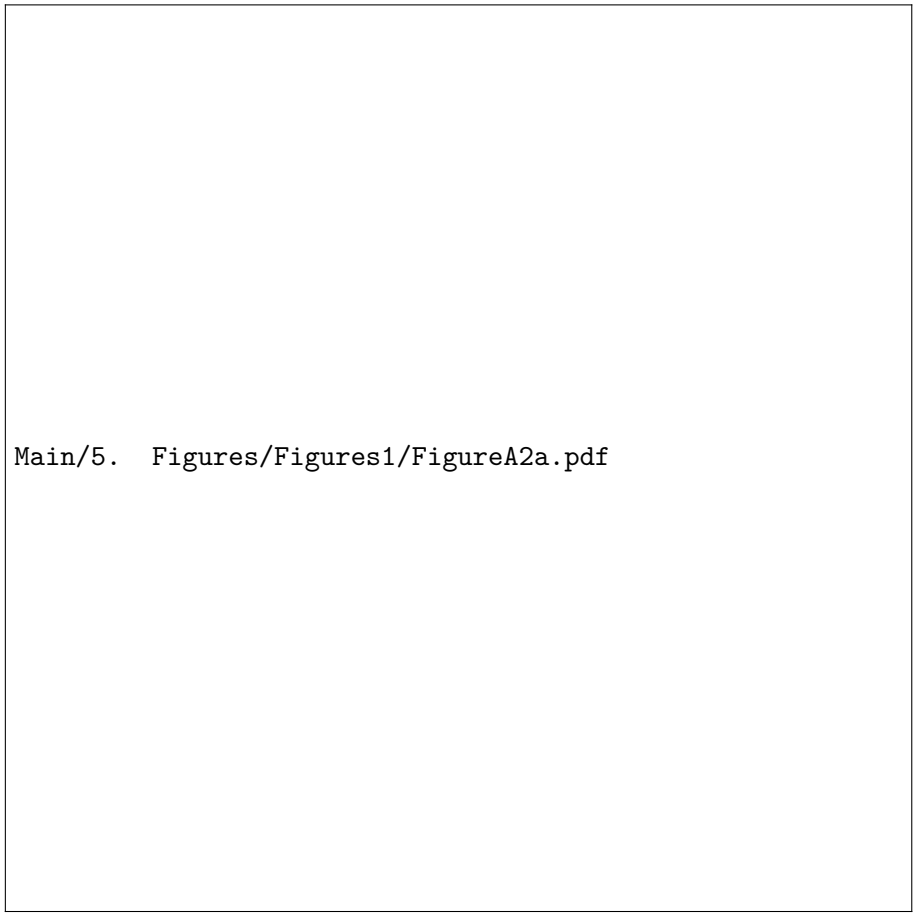
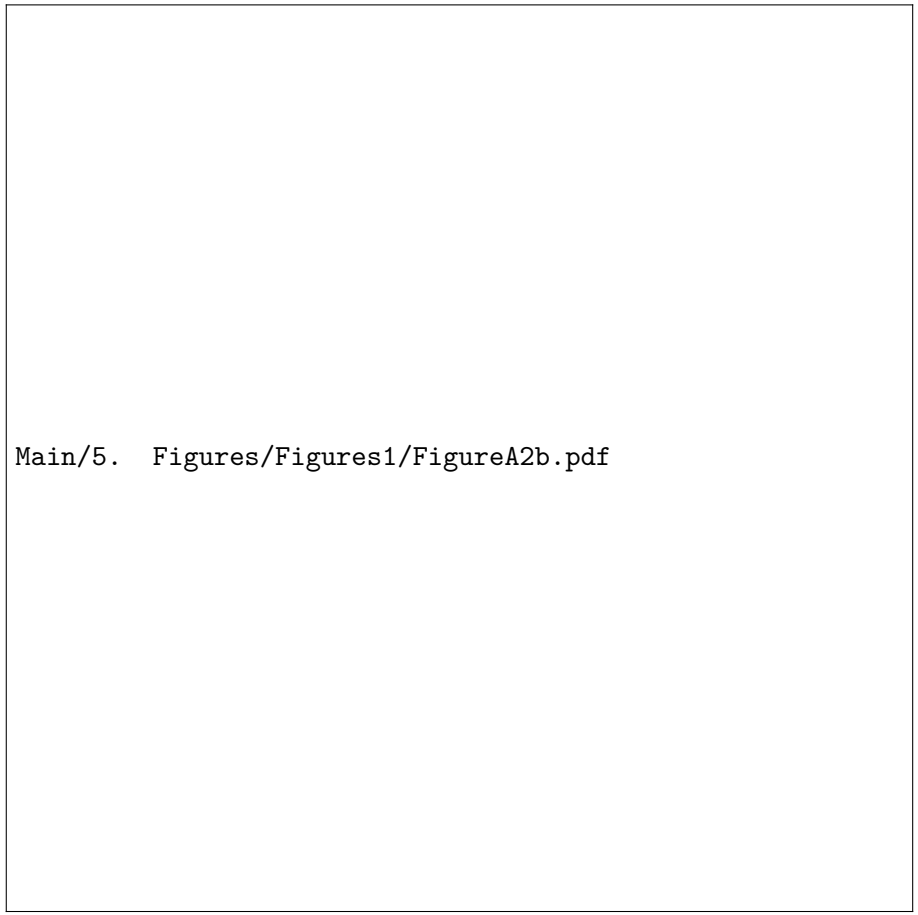


Figure A.1: School shutdown policy in the state of São Paulo (2009)

Source: Local newspapers. See https://www1.folha.uol.com.br/cotidiano/2009/08/602634-escolas-e-universidades-adiam-volta-as-aulas-devido-a-gripe-suina-veja-lista.shtml.



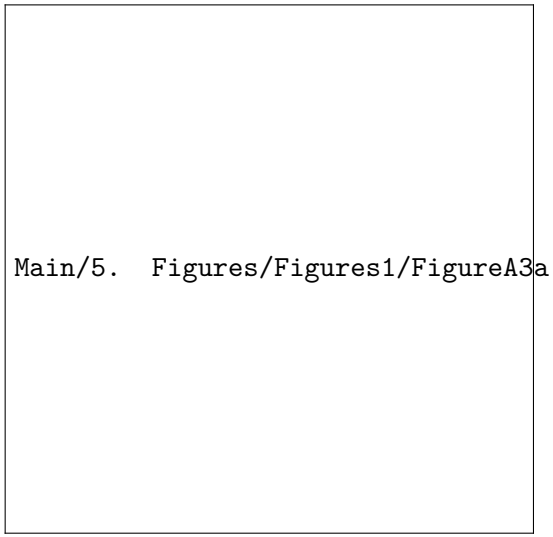
(a) Accumulated, April-July



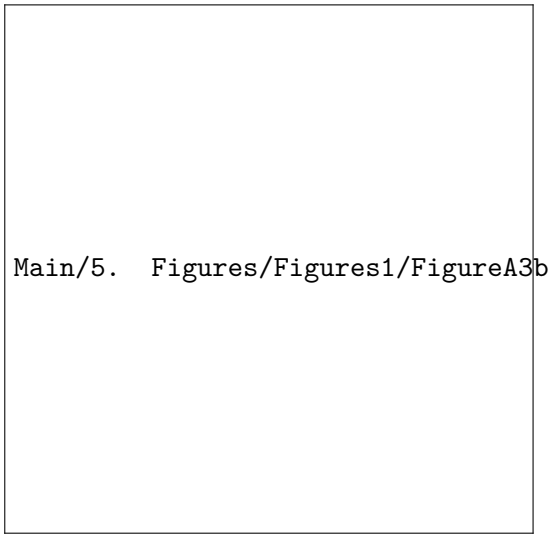
(b) Weekly, April-July

Note: The number of confirmed H1N1 cases per week are from https://datasus.saude.gov.br/informacoes-de-saude-tabnet/. (a) Average number of confirmed H1N1 cases between April and July 2009. (b) weekly number of cases between April and December 2009.

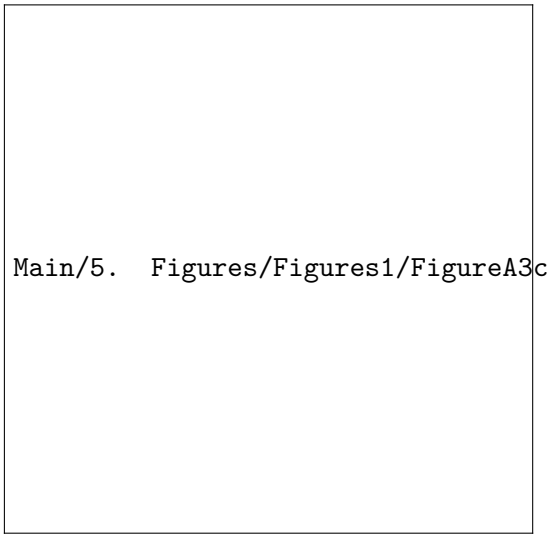
Figure A.2: H1N1 confirmed cases per 100.000 inhabitants (2009)



(a) Repetition



(b) Approval

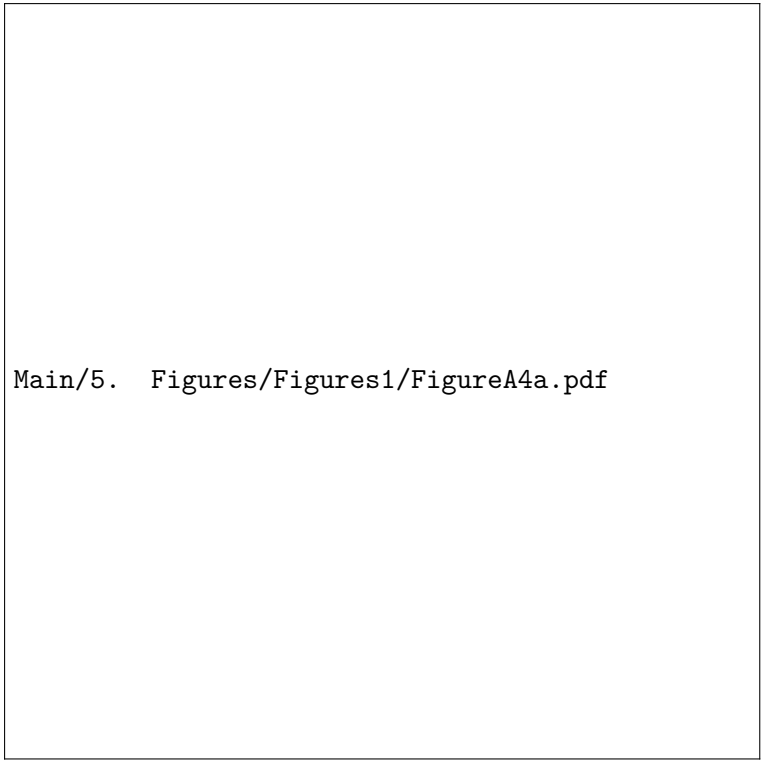


(c) Dropout

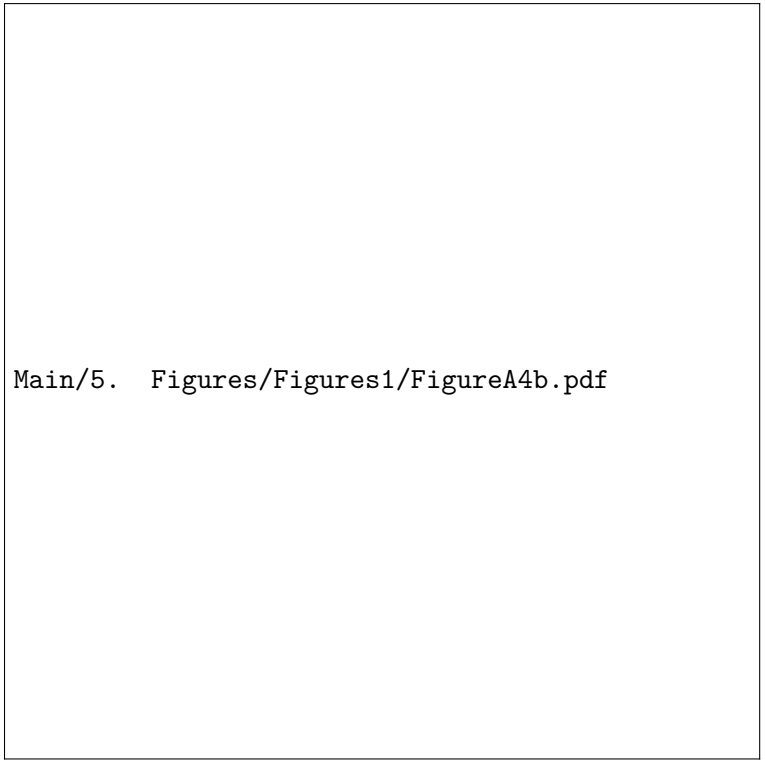
Figure A.3: Repetition, dropout and approval rates (%), fifth-grade (2007-2009)

Note: Data from INEP. Repetition, approval and dropout rates range from o to 100. The indicators for treatment and comparison groups is the average of a sample of locally-managed schools in the state of Sao Paulo.

Figure A.4: Performance in state and locally-managed schools, fifth-grade (2005-2009)



(a) Math



(b) Portuguese

Note: Data from *Prova Brasil*. The proficiency $G = 1$ and $G = 0$ is the average of the proficiency scores of state and locally-managed schools in Sao Paulo. The proficiency in Portuguese and Math are in SAEB scale.

Table A.1: Balance test: municipalities that extended the winter break versus municipalities that not (2009)

	(1) Comparison Group		(2) Treatment Group		T-test Difference
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
Average enrollment per school	629	316.33	12	531.22	-214.89***
		(7.52)		(62.36)	
Total enrollment	632	2,700.47	12	19,633.50	-16,933.03***
		(199.00)		(3,515.11)	
Teachers with tenure	565	0.39	12	0.60	-0.21**
		(0.01)		(0.10)	
H1N1 cases per 100,000 inhabitants	632	1.95	12	9.80	-7.85***
		(0.18)		(0.94)	
Population, in thousand	632	39.53	12	446.73	-407.19***
		(3.48)		(90.31)	
GDP per capita	610	26,116.72	12	50,073.24	-23,956.52***
		(524.71)		(6,472.35)	

Notes: *Prova Brasil*, Census of Education and IBGE for municipalities of the state of São Paulo. The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. The municipality of São Paulo is not included in the Table, as it had more than 11 million inhabitants in 2009 and its inclusion would distort the comparison between treatment and comparison municipalities.

Table A.2: Linear Regression of school characteristics (2007) on the decision to extend the winter-break in 2009

	Extended the winter break
Math, 5th grade	-0.002**
	0.001
Portuguese, 5th grade	0.002*
	0.001
Repetition - %	0.001
	0.001
Dropout - %	-0.006
	0.006
Class hours per day	-0.038***
	0.006
Students per teacher	0.000
	0.000
Lack of textbooks according to principals	0.000***
	0.000
Teachers classify the textbooks as great - %	0.000
	0.000
Teachers covered more than 80 percent of the curricula - %	0.000
	0.000
Principal managerial skills from teacher perspective - %	-0.093**
	0.032
Teacher with tenure - %	0.001***
	0.000
Student absenteeism as a big issue	0.001*
	0.000
Teacher absenteeism as a big issue	0.001**
	0.000
Deficit in learning is due to: students' low effort - %	-0.001***
	0.000
Deficit in learning is due to: students' bad behavior - %	0.000
	0.000
Students allocated into classrooms according to similar age	0.000
	0.000
GDP per capita	0.000***
	0.000
Population	0.000***
	0.000
H1N1 cases per 100.000 inhabitants (Late July 2009)	0.000
	0.000
Constant	0.300***
	0.074
Obs	2963
Adj. R-squared	0.596

Notes: Authors' estimate based on *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. The table shows the results of a linear regression at school level, in which the dependent variable assumes the value 1 if school is located in a municipality that opted to extend children's winter break and 0, otherwise. The sample includes all municipalities of São Paulo in which the data on population, H1N1 confirmed cases, GDP per capita and education data are available (516 municipalities).

Table A.3: Fifth-graders' characteristics, locally-managed schools (2009)

Variable	(1) Comparison Group N	Mean/SE	(2) Treatment Group N	Mean/SE	T-test Difference (1)-(2)
Proficiency in Math [SAEB scale 0 to 350]	2568	219.85	795	202.19	17.66***
		(0.40)		(0.56)	
Proficiency in Portuguese [SAEB scale 0 to 325]	2568	194.60	795	182.39	12.21***
		(0.33)		(0.52)	
Repetition - %	2567	5.95	794	10.75	-4.80***
		(0.12)		(0.30)	
Dropout - %	2567	0.18	794	0.39	-0.22***
		(0.01)		(0.03)	
a Approval - %	2567	93.87	794	88.85	5.02***
		(0.12)		(0.30)	
Parents encourage to study - %	2564	97.93	795	96.93	1.01***
		(0.05)		(0.08)	
Parents encourage to do the homework - %	2564	96.74	795	95.50	1.24***
		(0.06)		(0.10)	
Parents encourage to read - %	2564	95.01	795	94.61	0.40***
		(0.07)		(0.10)	
Parents encourage to go to school - %	2564	97.14	795	95.70	1.44***
		(0.06)		(0.10)	
Parents talk about what happens in the school - %	2564	84.07	795	84.89	-0.81***
		(0.14)		(0.18)	
White students - %	2565	45.38	795	38.34	7.04***
		(0.27)		(0.29)	
Student lives with mother (or legal responsible) - %	2564	94.83	795	94.51	0.32**
		(0.07)		(0.10)	
Computer in the household - %	2565	49.80	795	58.43	-8.63***
		(0.33)		(0.45)	
Students' mother finished high school - %	2564	33.97	795	37.20	-3.23***
		(0.30)		(0.46)	
Student did preschool - %	2564	83.40	795	75.94	7.46***
		(0.20)		(0.29)	
Student has ever repeated and 0, otherwise - %	2564	21.55	795	20.53	1.02**
		(0.21)		(0.29)	
Student has ever dropped and 0, otherwise - %	2564	4.86	795	7.11	-2.25***
		(0.08)		(0.15)	
Student works - %	2564	11.86	795	13.27	-1.41***
		(0.14)		(0.21)	
Students per class	2568	27.44	795	31.41	-3.97***
		(0.10)		(0.14)	
Class hours per day	2568	5.02	795	4.79	0.22***
		(0.01)		(0.01)	
Insufficient performance in Math - %	2566	35.52	795	49.47	-13.95***
		(0.32)		(0.49)	
Insufficient performance in Portuguese - %	2566	56.87	795	66.07	-9.21***
		(0.31)		(0.45)	
Teacher always corrects Portuguese homework - %	2564	84.00	795	78.27	5.74***
		(0.22)		(0.33)	
Teacher always corrects Math homework - %	2564	85.58	795	80.91	4.67***
		(0.21)		(0.30)	
Schools with computer lab - %	2568	58.68	795	93.58	-34.90***
		(0.97)		(0.87)	
Schools with science lab - %	2568	5.45	795	20.00	-14.55***
		(0.45)		(1.42)	
Schools sport court - %	2568	66.51	795	90.44	-23.93***
		(0.93)		(1.04)	
Schools with library - %	2568	24.65	795	23.40	1.25
		(0.85)		(1.50)	
Schools internet access - %	2568	90.50	795	93.71	-3.21***
		(0.58)		(0.86)	
Length of the school year (days)	2568	318.76	795	313.95	4.80***
		(0.21)		(0.53)	
Total enrollment, all grades	2568	486.22	795	872.01	-385.79***
		(5.46)		(12.41)	
GDP per capita of the municipality, in 2019 BRL	2440	30,945.36	795	57,707.66	-26,762.30***
		(314.88)		(430.57)	

Notes: *Prova Brasil* and Census of Education. Locally-managed schools in São Paulo. The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.4: Fifth-graders' characteristics, state and locally-managed schools in $G = 1$ (2009)

Variable	(1) Locally-managed N	(1) Locally-managed Mean/SE	(2) State-managed N	(2) State-managed Mean/SE	T-test Difference (1)-(2)
Proficiency in Math [SAEB scale 0 to 350]	1334	216.95	929	215.01	1.94**
		(0.54)		(0.62)	
Proficiency in Portuguese [SAEB scale 0 to 325]	1334	193.39	929	189.67	3.72***
		(0.46)		(0.52)	
Repetition - %	1334	5.69	929	6.10	-0.41*
		(0.16)		(0.19)	
Dropout - %	1334	0.21	929	0.17	0.04
		(0.02)		(0.02)	
Approval - %	1334	94.10	929	93.73	0.37
		(0.16)		(0.19)	
Parents encourage to study - %	1333	97.92	929	97.80	0.12
		(0.06)		(0.08)	
Parents encourage to do the homework - %	1333	96.72	929	96.36	0.36***
		(0.08)		(0.11)	
Parents encourage to read - %	1333	94.96	929	95.62	-0.66***
		(0.09)		(0.10)	
Parents encourage to go to school - %	1333	97.15	929	96.81	0.34***
		(0.07)		(0.09)	
Parents talk about what happens in the school - %	1333	83.36	929	85.08	-1.72***
		(0.19)		(0.20)	
White students - %	1333	44.18	929	44.76	-0.58
		(0.36)		(0.43)	
Student lives with mother (or legal responsible) - %	1333	95.11	929	94.95	0.16
		(0.09)		(0.10)	
Computer in the household - %	1333	53.27	929	52.39	0.88
		(0.45)		(0.53)	
Students' mother finished high school - %	1333	36.09	929	35.75	0.34
		(0.43)		(0.49)	
Student did preschool - %	1333	82.26	929	81.52	0.74*
		(0.28)		(0.33)	
Student has ever repeated and 0, otherwise - %	1333	19.56	929	16.40	3.16***
		(0.28)		(0.30)	
Student has ever dropped and 0, otherwise - %	1333	4.90	929	5.79	-0.89***
		(0.11)		(0.14)	
Student works - %	1333	11.15	929	12.66	-1.51***
		(0.17)		(0.23)	
Students per class	1334	28.71	929	28.82	-0.10
		(0.14)		(0.16)	
Class hours per day	1334	4.91	929	5.31	-0.40***
		(0.02)		(0.03)	
Insufficient performance in Math - %	1334	37.59	929	40.02	-2.43***
		(0.44)		(0.50)	
Insufficient performance in Portuguese - %	1334	57.73	929	60.46	-2.73***
		(0.43)		(0.48)	
Teacher always corrects Portuguese homework - %	1333	81.95	929	82.10	-0.16
		(0.31)		(0.36)	
Teacher always corrects Math homework - %	1333	83.62	929	83.89	-0.27
		(0.30)		(0.34)	
Schools with computer lab - %	1334	57.80	929	92.25	-34.45***
		(1.35)		(0.88)	
Schools with science lab - %	1334	6.90	929	6.89	0.01
		(0.69)		(0.83)	
Schools sport court - %	1334	61.69	929	84.39	-22.70***
		(1.33)		(1.19)	
Schools with library - %	1334	25.86	929	2.91	22.96***
		(1.20)		(0.55)	
Schools internet access - %	1334	88.46	929	98.28	-9.82***
		(0.88)		(0.43)	
Length of the school year (days)	1334	320.22	929	315.01	5.21***
		(0.34)		(0.25)	
Total enrollment, all grades	1334	541.53	929	638.05	-96.52***
		(8.28)		(12.99)	
GDP per capita of the municipality, in 2019 BRL	1288	33,284.83	914	33,830.75	-545.92
		(370.67)		(434.43)	

Notes: *Prova Brasil* and Census of Education. State and locally-managed schools in São Paulo. Group of municipalities in $G = 1$ (Table 1.2). The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.5: Fifth-graders' characteristics, state and locally-managed schools in $G = 0$ (2009)

Variable	(1) Locally-managed N	(1) Locally-managed Mean/SE	(2) State-managed N	(2) State-managed Mean/SE	T-test Difference (1)-(2)
Proficiency in Math [SAEB scale 0 to 350]	759	201.11	868	210.28	-9.16***
		(0.58)		(0.54)	
Proficiency in Portuguese [SAEB scale 0 to 325]	759	181.48	868	188.01	-6.53***
		(0.53)		(0.48)	
Repetition - %	758	11.40	868	5.78	5.62***
		(0.30)		(0.18)	
Dropout - %	758	0.40	868	0.37	0.03
		(0.03)		(0.03)	
Approval - %	758	88.20	868	93.85	-5.65***
		(0.31)		(0.19)	
Parents encourage to study - %	759	96.81	867	97.58	-0.77***
		(0.09)		(0.08)	
Parents encourage to do the homework - %	759	95.43	867	96.22	-0.79***
		(0.10)		(0.12)	
Parents encourage to read - %	759	94.64	867	95.38	-0.74***
		(0.10)		(0.10)	
Parents encourage to go to school - %	759	95.64	867	96.40	-0.76***
		(0.11)		(0.09)	
Parents talk about what happens in the school - %	759	85.10	867	85.08	0.02
		(0.18)		(0.16)	
White students - %	759	38.02	867	40.36	-2.34***
		(0.29)		(0.32)	
Student lives with mother (or legal responsible) - %	759	94.42	867	94.78	-0.36***
		(0.11)		(0.09)	
Computer in the household - %	759	58.81	867	61.20	-2.39***
		(0.43)		(0.44)	
Students' mother finished high school - %	759	36.59	867	39.63	-3.04***
		(0.43)		(0.45)	
Student did preschool - %	759	75.21	867	79.90	-4.70***
		(0.29)		(0.30)	
Student has ever repeated and 0, otherwise - %	759	21.16	867	14.98	6.18***
		(0.32)		(0.26)	
Student has ever dropped and 0, otherwise - %	759	7.40	867	6.42	0.98***
		(0.16)		(0.14)	
Student works - %	759	13.42	867	12.09	1.33***
		(0.22)		(0.17)	
Students per class	759	31.76	868	31.37	0.39*
		(0.14)		(0.14)	
Class hours per day	759	4.74	868	5.17	-0.43***
		(0.02)		(0.02)	
Insufficient performance in Math - %	759	50.41	868	42.96	7.45***
		(0.51)		(0.46)	
Insufficient performance in Portuguese - %	759	66.70	868	61.64	5.05***
		(0.47)		(0.43)	
Teacher always corrects Portuguese homework - %	759	78.19	867	80.30	-2.12***
		(0.35)		(0.31)	
Teacher always corrects Math homework - %	759	80.86	867	82.43	-1.56***
		(0.32)		(0.30)	
Schools with computer lab - %	759	94.07	868	89.06	5.02***
		(0.86)		(1.06)	
Schools with science lab - %	759	20.95	868	11.64	9.31***
		(1.48)		(1.09)	
Schools sport court - %	759	89.99	868	85.83	4.16**
		(1.09)		(1.18)	
Schools with library - %	759	20.95	868	3.80	17.15***
		(1.48)		(0.65)	
Schools internet access - %	759	93.68	868	97.47	-3.79***
		(0.88)		(0.53)	
Length of the school year (days)	759	313.74	868	313.50	0.24
		(0.56)		(0.28)	
Total enrollment, all grades	759	888.28	868	854.12	34.16*
		(12.22)		(15.19)	
GDP per capita of the municipality, in 2019 BRL	759	58,012.21	868	56,747.25	1,264.96***
		(384.71)		(306.31)	

Notes: *Prova Brasil* and Census of Education. State and locally-managed schools in São Paulo. Group of municipalities in $G = 0$ (Table 1.2). The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.6: Fifth-graders' characteristics, state-managed schools (2009)

Variable	(1) State-managed in G = 0 N	Mean/SE	(2) State-managed in G = 1 N	Mean/SE	T-test Difference (1)-(2)
Proficiency in Math [SAEB scale 0 to 350]	868	210.28	929	215.01	-4.73***
		(0.54)		(0.62)	
Proficiency in Portuguese [SAEB scale 0 to 325]	868	188.01	929	189.67	-1.66**
		(0.48)		(0.52)	
Repetition - %	868	5.78	929	6.10	-0.32
		(0.18)		(0.19)	
Dropout - %	868	0.37	929	0.17	0.20***
		(0.03)		(0.02)	
Approval - %	868	93.85	929	93.73	0.12
		(0.19)		(0.19)	
Parents encourage to study - %	867	97.58	929	97.80	-0.22**
		(0.08)		(0.08)	
Parents encourage to do the homework - %	867	96.22	929	96.36	-0.14
		(0.12)		(0.11)	
Parents encourage to read - %	867	95.38	929	95.62	-0.24*
		(0.10)		(0.10)	
Parents encourage to go to school - %	867	96.40	929	96.81	-0.41***
		(0.09)		(0.09)	
Parents talk about what happens in the school - %	867	85.08	929	85.08	-0.00
		(0.16)		(0.20)	
White students - %	867	40.36	929	44.76	-4.40***
		(0.32)		(0.43)	
Student lives with mother (or legal responsible) - %	867	94.78	929	94.95	-0.17
		(0.09)		(0.10)	
Computer in the household - %	867	61.20	929	52.39	8.81***
		(0.44)		(0.53)	
Students' mother finished high school - %	867	39.63	929	35.75	3.88***
		(0.45)		(0.49)	
Student did preschool - %	867	79.90	929	81.52	-1.62***
		(0.30)		(0.33)	
Student has ever repeated and 0, otherwise - %	867	14.98	929	16.40	-1.42***
		(0.26)		(0.30)	
Student has ever dropped and 0, otherwise - %	867	6.42	929	5.79	0.64***
		(0.14)		(0.14)	
Student works - %	867	12.09	929	12.66	-0.57**
		(0.17)		(0.23)	
Students per class	868	31.37	929	28.82	2.55***
		(0.14)		(0.16)	
Class hours per day	868	5.17	929	5.31	-0.14***
		(0.02)		(0.03)	
Insufficient performance in Math - %	868	42.96	929	40.02	2.93***
		(0.46)		(0.50)	
Insufficient performance in Portuguese - %	868	61.64	929	60.46	1.18*
		(0.43)		(0.48)	
Teacher always corrects Portuguese homework - %	867	80.30	929	82.10	-1.80***
		(0.31)		(0.36)	
Teacher always corrects Math homework - %	867	82.43	929	83.89	-1.46***
		(0.30)		(0.34)	
Schools with computer lab - %	868	89.06	929	92.25	-3.19**
		(1.06)		(0.88)	
Schools with science lab - %	868	11.64	929	6.89	4.75***
		(1.09)		(0.83)	
Schools sport court - %	868	85.83	929	84.39	1.44
		(1.18)		(1.19)	
Schools with library - %	868	3.80	929	2.91	0.90
		(0.65)		(0.55)	
Schools internet access - %	868	97.47	929	98.28	-0.81
		(0.53)		(0.43)	
Length of the school year (days)	868	313.50	929	315.01	-1.52***
		(0.28)		(0.25)	
Total enrollment, all grades	868	854.12	929	638.05	216.07***
		(15.19)		(12.99)	
GDP per capita of the municipality, in 2019 BRL	868	56,747.25	914	33,830.75	22,916.50***
		(306.31)		(434.43)	

Notes: *Prova Brasil* and Census of Education. State-managed schools in São Paulo. The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.7: Teachers' and principals' characteristics in locally-managed schools (2009)

Variable	(1) Comparison Group N	(1) Comparison Group Mean/SE	(2) Treatment Group N	(2) Treatment Group Mean/SE	T-test Difference (1)-(2)
Teacher with tenure - %	2348	48.73	719	67.44	-18.71***
		(0.87)		(1.21)	
Teacher with less than 40 years old - %	2353	48.53	722	38.43	10.10***
		(0.75)		(1.17)	
Principal managerial skills from teacher perspective	2253	0.76	643	0.72	0.04***
		(0.00)		(0.01)	
Index for the violence the teacher faces in the school	2344	0.14	716	0.28	-0.14***
		(0.01)		(0.01)	
Teacher expects that almost all students will finish 9th grade - %	2326	88.76	721	87.36	1.41
		(0.48)		(0.78)	
Teacher expects that almost all students will finish high school - %	2312	60.72	715	53.35	7.37***
		(0.76)		(1.26)	
Teachers covered more than 80 percent of the curricula - %	2351	54.67	722	45.16	9.51***
		(0.78)		(1.23)	
Teachers always participate of the work decisions - %	2236	56.40	659	54.45	1.95
		(0.80)		(1.38)	
Teachers say that all the students have textbooks - %	2154	70.75	644	64.69	6.06***
		(0.83)		(1.45)	
Teachers classify the textbooks as great - %	2178	18.69	667	15.17	3.52**
		(0.68)		(1.07)	
Teachers' salary is less than 3 minimum wage - %	1980	33.07	665	13.49	19.58***
		(0.89)		(0.99)	
Deficit in learning is due to: students' low effort - %	2348	81.72	721	76.33	5.39***
		(0.59)		(0.98)	
Deficit in learning is due to: students' absenteeism - %	2210	31.76	650	36.09	-4.33**
		(0.91)		(1.61)	
Deficit in learning is due to: students' bad behavior - %	2345	56.91	718	61.24	-4.34***
		(0.76)		(1.16)	
Teachers with the correct degree to teach Portuguese - %	2133	69.39	662	74.10	-4.71***
		(0.78)		(1.52)	
Teachers with the correct degree to teach Math - %	2133	63.32	662	69.54	-6.22***
		(0.81)		(1.59)	
Principal has organized Teachers' training last two years, %	1716	56.99	557	64.63	-7.64***
		(1.20)		(2.03)	
Lack of textbooks according to principals, %	1671	29.20	553	51.72	-22.51***
		(1.11)		(2.13)	
Principal was appointed for the position, %	1731	47.66	565	14.51	33.15***
		(1.20)		(1.48)	
Teacher absenteeism as a big issue, %	1744	8.08	561	26.38	-18.30***
		(0.65)		(1.86)	
Student absenteeism as a big issue, %	1746	4.41	566	8.30	-3.89***
		(0.49)		(1.16)	
Students allocated into classrooms according to similar age, %	1660	35.00	549	27.69	7.31***
		(1.17)		(1.91)	
Students allocated into classrooms according to hetero. performance, %	1660	41.08	549	60.29	-19.21***
		(1.21)		(2.09)	

Notes: *Prova Brasil* and Census of Education. Locally-managed schools in São Paulo. The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.8: Teachers' and principals' characteristics in state and locally-managed schools in $G = 1$ (2009)

Variable	(1) Locally-managed N	(1) Locally-managed Mean/SE	(2) State-managed N	(2) State-managed Mean/SE	T-test Difference (1)-(2)
Teacher with tenure - %	1220	45.65	852	57.22	-11.57***
		(1.24)		(1.22)	
Teacher with less than 40 years old - %	1224	52.24	852	24.83	27.41***
		(1.02)		(1.04)	
Principal managerial skills from teacher perspective	1170	0.74	809	0.78	-0.04***
		(0.00)		(0.01)	
Index for the violence the teacher faces in the school	1220	0.15	851	0.12	0.03**
		(0.01)		(0.01)	
Teacher expects that almost all students will finish 9th grade - %	1212	87.37	850	89.54	-2.16**
		(0.69)		(0.71)	
Teacher expects that almost all students will finish high school - %	1203	56.83	843	66.06	-9.23***
		(1.06)		(1.19)	
Teachers covered more than 80 percent of the curricula - %	1222	51.13	852	51.57	-0.45
		(1.05)		(1.24)	
Teachers always participate of the work decisions - %	1170	54.84	810	59.90	-5.06***
		(1.09)		(1.24)	
Teachers say that all the students have textbooks - %	1133	64.71	787	76.00	-11.29***
		(1.19)		(1.21)	
Teachers classify the textbooks as great - %	1126	15.10	791	24.19	-9.09***
		(0.84)		(1.15)	
Teachers' salary is less than 3 minimum wage - %	1073	25.75	731	26.34	-0.59
		(1.10)		(1.30)	
Deficit in learning is due to: students' low effort - %	1219	80.67	853	77.90	2.77**
		(0.82)		(1.00)	
Deficit in learning is due to: students' absenteeism - %	1153	37.31	808	35.41	1.90
		(1.32)		(1.59)	
Deficit in learning is due to: students' bad behavior - %	1216	58.82	851	54.25	4.57***
		(1.02)		(1.23)	
Teachers with the correct degree to teach Portuguese - %	1117	71.88	748	64.38	7.50***
		(1.01)		(1.26)	
Teachers with the correct degree to teach Math - %	1117	64.75	748	57.92	6.83***
		(1.07)		(1.31)	
Principal has organized Teachers' training last two years, %	911	60.26	865	65.55	-5.29**
		(1.62)		(1.62)	
Lack of textbooks according to principals, %	891	34.01	869	25.66	8.35***
		(1.59)		(1.48)	
Principal was appointed for the position, %	927	41.75	869	8.17	33.58***
		(1.62)		(0.93)	
Teacher absenteeism as a big issue, %	928	8.41	871	19.75	-11.34***
		(0.91)		(1.35)	
Student absenteeism as a big issue, %	927	5.39	874	6.98	-1.59
		(0.74)		(0.86)	
Students allocated into classrooms according to similar age, %	876	39.16	855	36.96	2.20
		(1.65)		(1.65)	
Students allocated into classrooms according to hetero. performance, %	876	39.50	855	38.60	0.90
		(1.65)		(1.67)	

Notes: *Prova Brasil* and Census of Education. State and locally-managed schools in São Paulo. Group of municipalities in $G = 1$ (Table 1.2). The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.9: Teachers' and principals' characteristics in state and locally-managed schools in $G = 0$ (2009)

Variable	(1) Locally-managed N	(1) Locally-managed Mean/SE	(2) State-managed N	(2) State-managed Mean/SE	T-test Difference (1)-(2)
Teacher with tenure - %	681	69.63	772	50.81	18.82***
		(1.25)		(1.18)	
Teacher with less than 40 years old - %	686	36.58	773	27.70	8.88***
		(1.18)		(0.94)	
Principal managerial skills from teacher perspective	608	0.72	709	0.75	-0.03***
		(0.01)		(0.01)	
Index for the violence the teacher faces in the school	680	0.29	769	0.26	0.03
		(0.01)		(0.01)	
Teacher expects that almost all students will finish 9th grade - %	685	86.80	772	88.20	-1.40
		(0.83)		(0.69)	
Teacher expects that almost all students will finish high school - %	680	51.58	768	64.85	-13.27***
		(1.29)		(1.07)	
Teachers covered more than 80 percent of the curricula - %	686	42.18	773	51.28	-9.10***
		(1.26)		(1.13)	
Teachers always participate of the work decisions - %	625	53.71	722	57.69	-3.98**
		(1.43)		(1.24)	
Teachers say that all the students have textbooks - %	606	64.71	683	67.35	-2.64
		(1.49)		(1.31)	
Teachers classify the textbooks as great - %	630	15.19	729	21.32	-6.13***
		(1.10)		(1.11)	
Teachers' salary is less than 3 minimum wage - %	625	12.50	723	24.54	-12.03***
		(0.97)		(1.14)	
Deficit in learning is due to: students' low effort - %	685	76.95	773	73.02	3.93***
		(1.01)		(1.00)	
Deficit in learning is due to: students' absenteeism - %	614	38.16	707	35.00	3.17
		(1.70)		(1.55)	
Deficit in learning is due to: students' bad behavior - %	682	63.12	770	55.03	8.09***
		(1.19)		(1.09)	
Teachers with the correct degree to teach Portuguese - %	626	73.07	667	66.15	6.93***
		(1.59)		(1.22)	
Teachers with the correct degree to teach Math - %	626	68.44	667	61.63	6.81***
		(1.66)		(1.26)	
Principal has organized Teachers' training last two years, %	540	65.19	794	62.97	2.21
		(2.05)		(1.71)	
Lack of textbooks according to principals, %	534	53.00	801	26.72	26.28***
		(2.16)		(1.56)	
Principal was appointed for the position, %	548	15.69	797	7.28	8.42***
		(1.56)		(0.92)	
Teacher absenteeism as a big issue, %	542	29.52	802	18.45	11.07***
		(1.96)		(1.37)	
Student absenteeism as a big issue, %	549	9.11	805	6.96	2.15
		(1.23)		(0.90)	
Students allocated into classrooms according to similar age, %	530	27.92	773	36.61	-8.69***
		(1.95)		(1.73)	
Students allocated into classrooms according to hetero. performance, %	530	60.57	773	42.69	17.88***
		(2.12)		(1.78)	

Notes: *Prova Brasil* and Census of Education. State and locally-managed schools in São Paulo. Group of municipalities in $G = 0$ (Table 1.2). The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.10: Teachers' and principals' characteristics of state-managed schools (2009)

Variable	(1) State-managed, G=0 N	Mean/SE	(2) State-managed, G=1 N	Mean/SE	T-test Difference (1)-(2)
Teacher with tenure - %	772	50.81	852	57.22	-6.41***
		(1.18)		(1.22)	
Teacher with less than 40 years old - %	773	27.70	852	24.83	2.87**
		(0.94)		(1.04)	
Principal managerial skills from teacher perspective	709	0.75	809	0.78	-0.04***
		(0.01)		(0.01)	
Index for the violence the teacher faces in the school	769	0.26	851	0.12	0.14***
		(0.01)		(0.01)	
Teacher expects that almost all students will finish 9th grade - %	772	88.20	850	89.54	-1.34
		(0.69)		(0.71)	
Teacher expects that almost all students will finish high school - %	768	64.85	843	66.06	-1.22
		(1.07)		(1.19)	
Teachers covered more than 80 percent of the curricula - %	773	51.28	852	51.57	-0.29
		(1.13)		(1.24)	
Teachers always participate of the work decisions - %	722	57.69	810	59.90	-2.21
		(1.24)		(1.24)	
Teachers say that all the students have textbooks - %	683	67.35	787	76.00	-8.65***
		(1.31)		(1.21)	
Teachers classify the textbooks as great - %	729	21.32	791	24.19	-2.87*
		(1.11)		(1.15)	
Teachers' salary is less than 3 minimum wage - %	723	24.54	731	26.34	-1.80
		(1.14)		(1.30)	
Deficit in learning is due to: students' low effort - %	773	73.02	853	77.90	-4.88***
		(1.00)		(1.00)	
Deficit in learning is due to: students' absenteeism - %	707	35.00	808	35.41	-0.41
		(1.55)		(1.59)	
Deficit in learning is due to: students' bad behavior - %	770	55.03	851	54.25	0.78
		(1.09)		(1.23)	
Teachers with the correct degree to teach Portuguese - %	667	66.15	748	64.38	1.77
		(1.22)		(1.26)	
Teachers with the correct degree to teach Math - %	667	61.63	748	57.92	3.71**
		(1.26)		(1.31)	
Principal has organized Teachers' training last two years, %	794	62.97	865	65.55	-2.58
		(1.71)		(1.62)	
Lack of textbooks according to principals, %	801	26.72	869	25.66	1.05
		(1.56)		(1.48)	
Principal was appointed for the position, %	797	7.28	869	8.17	-0.89
		(0.92)		(0.93)	
Teacher absenteeism as a big issue, %	802	18.45	871	19.75	-1.29
		(1.37)		(1.35)	
Student absenteeism as a big issue, %	805	6.96	874	6.98	-0.02
		(0.90)		(0.86)	
Students allocated into classrooms according to similar age, %	773	36.61	855	36.96	-0.35
		(1.73)		(1.65)	
Students allocated into classrooms according to hetero. performance, %	773	42.69	855	38.60	4.09*
		(1.78)		(1.67)	

Notes: *Prova Brasil* and Census of Education. State-managed schools in São Paulo. The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.11: Testing parallel trends assumption on students' performance prior to 2009 H1N1 outbreak

	Fifth-graders				Ninth-graders			
	Math		Portuguese		Math		Portuguese	
State-managed	-4.564**	3.873	-2.315	5.804	-3.199	-4.708	-0.578	1.783
	1.72	6.31	1.49	5.5	2.16	9.61	1.96	8.69
Post-treatment year (2007)	12.482***	14.960*	-0.166	2.426	3.422	5.269	6.057**	11.212
	1.68	6.18	1.45	5.38	2.18	9.99	1.98	9.03
State-managed × post-treatment	-6.250**	-10.219	-5.844**	-11.406	-2.917	-6.937	-2.914	-10.515
	2.38	8.71	2.06	7.58	2.82	13.18	2.56	11.91
G = 1		9.08		6.78		-3.204		-2.634
		4.74		4.13		7.65		6.91
State-managed × G = 1		-8.437		-8.119		1.509		-2.362
		6.54		5.69		9.85		8.9
Post-treatment × with G = 1		-2.478		-2.592		-1.847		-5.155
		6.39		5.57		10.22		9.24
Triple DiD		3.969		5.562		4.02		7.601
		9.02		7.85		13.48		12.18
N	554	594	554	594	485	506	485	506
r2_a	0.171	0.174	0.067	0.066	0.027	0.023	0.031	0.03

Notes: Authors' estimate based on *Prova Brasil*. *G* as defined in the empirical strategy (Table 1.2). Regression run at municipality level for the years of 2005 and 2007 as data at school level is only available for state-managed network since 2007. Sample of municipalities with at least one state and one locally-managed school. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.12: Testing parallel trends assumption on approval, repetition and dropout prior to 2009 H1N1 outbreak

	Fifth-graders						Ninth-graders					
	Approval		Repetition		Dropout		Approval		Repetition		Dropout	
State-managed	-2.489***	5.133***	2.439***	-5.162***	0.05	0.03	-9.896***	-5.514***	7.910***	4.315***	1.986***	1.199***
	0.27	0.37	0.27	0.37	0.04	0.07	0.55	0.57	0.51	0.53	0.22	0.22
Post-treatment year (2008)	0.618**	2.196***	-0.583*	-2.042***	-0.035	-0.154*	0.442	4.298***	-0.208	-4.151***	-0.234	-0.147
	0.24	0.39	0.24	0.38	0.04	0.07	0.62	0.62	0.57	0.58	0.25	0.24
State-managed × post-treatment	0.820*	0.455	-0.774*	-0.498	-0.046	0.043	1.864*	-1.185	-1.547*	1.418	-0.317	-0.232
	0.37	0.52	0.36	0.51	0.05	0.1	0.74	0.8	0.68	0.74	0.3	0.31
G = 1		1.901		-1.572		-0.329		14.575***		-11.341**		-3.234*
		2.09		2.04		0.38		3.88		3.59		1.51
State-managed × G = 1		-7.622***		7.601***		0.02		-4.382***		3.595***		0.787*
		0.48		0.47		0.09		0.83		0.77		0.32
Post-treatment × with G = 1		-1.577***		1.459**		0.119		-3.855***		3.942***		-0.087
		0.47		0.46		0.09		0.91		0.85		0.36
Triple DiD		0.365		-0.277		-0.089		3.049**		-2.965**		-0.084
		0.66		0.65		0.12		1.13		1.05		0.44
N	5275	8487	5275	8487	5275	8487	3161	5841	3161	5841	3161	5841
r2_a	0.167	0.196	0.167	0.195	0.04	0.016	0.271	0.244	0.234	0.217	0.145	0.089

Notes: Authors' estimate based on *Prova Brasil*. *G* as defined in the empirical strategy (Table 1.2) . Regression run at school level for the years of 2007 and 2008. Sample of municipalities with at least one state and one locally-managed school. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A.13: Impact of school shutdowns on students' learning, fifth-grade

	Math					Portuguese				
	DiD	DiD	DiD	Triple D	Triple D	DiD	DiD	DiD	Triple D	Triple D
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Placebo	0.27					0.8				
	(0.80)					(0.53)				
H1N1		-3.28**	-2.82**	-4.48***	-4.09***		-0.53	-0.34	-3.47***	-4.09***
		(0.03)	(0.02)	(0.00)	(0.00)		(0.52)	(0.72)	(0.00)	(0.00)
N. schools	5291	3808	3808	5032	5032	5291	3808	3808	5032	5032
Adj. R-squared	0.6	0.8	0.8	0.8	0.7	0.6	0.8	0.8	0.8	0.7
Specifications										
(A) Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(B) Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(C) % teachers in both networks	No	No	Yes	No	Yes	No	No	Yes	No	Yes
(D) % teachers management	No	No	Yes	No	Yes	No	No	Yes	No	Yes
(E) School FE	No	No	No	No	Yes	No	No	No	No	Yes

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. p-value in parenthesis. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. The rows (A), (B), (C), (D), and (E) indicate the controls included in the regression. (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented. The row Placebo shows the estimates in which the pre-treatment year is 2005 and the post-treatment year is 2007.

Table A.14: Impact of school shutdowns on approval, repetition and dropout, fifth-grade

	Approval				Repetition				Dropout			
	Triple D	DiD	Triple D	Triple D	Triple D	DiD	Triple D	Triple D	Triple D	DiD	Triple D	Triple D
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Placebo	0.627				-0.399				-0.229**			
	0.27				0.479				0.026			
H1N1		1.220*	0.909	0.032		-1.219*	-1.116	-0.346		-0.234*	-0.256*	-0.054
		0.076	0.323	0.971		0.064	0.215	0.681		0.081	0.097	0.596
N. schools	7,407	3,809	5,032	5,032	7,407	3,924	5,132	5,132	7,407	4,314	5,582	5,582
R2	0.30	0.50	0.40	0.10	0.30	0.50	0.40	0.10	0.00	0.00	0.00	0.00
Treatment Group before the school shutdowns (2007)												
Mean	90.97	86.36	90.93	90.93	8.76	13.48	8.78	8.78	0.28	0.52	0.29	0.29
Standard Deviation	6.78	11.31	6.86	6.86	6.67	10.97	6.74	6.74	0.80	3.57	0.81	0.81
Estimate of ATT (in sd)	0.09	0.11	0.13	0.00	-0.06	-0.11	-0.17	-0.05	-0.29	-0.07	-0.31	-0.07
Specifications												
(A) Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(B) Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(C) % teachers in both networks	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
(D) % teachers management	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
(E) School FE	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. p-value in parenthesis. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. The rows (A), (B), (C), (D), and (E) indicate the controls included in the regression. (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented. The row Placebo shows the estimates in which the pre-treatment year is 2007 and the post-treatment year is 2008.

Table A.15: Impact of school shutdowns on standardized proficiency, fifth-grade

Estimated decrease in Math and Portuguese Proficiency, SAEB scale								
	DiD	DiD	DiD	Triple D	Triple D	Triple D	Triple D	Triple D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
H1N1	-0.09**	-0.09**	-0.08**	-0.15***	-0.15***	-0.14***	-0.14***	-0.13***
	(0.03)	(0.02)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
95 CI	[-0.2,-0.0]	[-0.2,-0.0]	[-0.2,-0.0]	[-0.2,-0.1]	[-0.2,-0.1]	[-0.2,-0.1]	[-0.2,-0.1]	[-0.2,-0.0]
N. schools	3808	3808	3808	5032	5032	5032	5032	5032
R2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7
Proficiency - Treatment Group before the school shutdowns (2007)								
Mean	4.84	4.84	4.84	4.92	4.92	4.92	4.92	4.92
Sd	0.57	0.57	0.57	0.58	0.58	0.58	0.58	0.58
ATT est (in sd)	-0.16	-0.16	-0.13	-0.26	-0.25	-0.25	-0.24	-0.22
Specifications								
(A) Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(B) Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(C) % teachers in both networks	No	Yes	Yes	No	Yes	No	Yes	Yes
(D) % teachers management	No	No	Yes	No	No	Yes	Yes	Yes
(E) School FE	No	No	No	No	No	No	No	Yes

Notes: Authors' estimate based on data from *Prova Brasil*, Census of Education and IBGE. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. p-value in parenthesis. All regressions are weighted by fifth-grade enrollment at school level. Standard errors clustered at municipality level. Math performance on a scale from 0 to 350 (SAEB scale). Portuguese performance on a scale from 0 to 325 (SAEB scale). The Columns DiD show the estimates for equation 1.1 and Columns Triple D for equation 1.2. The sample of municipalities and schools included in the analysis are detailed in Table 1.2. The rows (A), (B), (C), (D), and (E) indicate the controls included in the regression. (A) municipal fixed effects. (B) students', teachers', schools' and principals' characteristics. (C) the percentage of teachers that work in a state and a locally-managed school at the same time. (D) the percentage of teachers that work in a state-managed school that implemented the managerial practices intervention. (E) schools' fixed effects. All triple DiD estimates exclude state-managed schools in which the state government managerial practices intervention was implemented.

B Appendix to Chapter 2

Table B.1: Educational indicators, first to fifth grades, (2007-2019)

	Age-grade distortion			Repetition			Approval			Dropout		
	Brasil	PE	Recife	Brasil	PE	Recife	Brasil	PE	Recife	Brasil	PE	Recife
2007	25.0	34.3	20.1	12.5	18.3	8.7	84.5	75.5	88.4	3.1	6.2	2.9
2008	19.7	25.8	19.5	11.7	16.8	6.7	85.5	77.8	90.7	2.7	5.4	2.6
2009	20.8	28.5	19.4	10.4	14.0	6.8	87.5	82.0	91.2	2.1	4.0	2.0
2010	20.6	28.0	19.0	9.1	11.8	7.7	89.2	85.1	90.9	1.7	3.1	1.4
2011	19.5	26.2	19.0	7.8	11.1	9.8	90.8	86.4	88.9	1.4	2.5	1.3
2012	18.0	24.4	20.3	7.4	11.6	9.6	91.2	86.0	88.9	1.4	2.4	1.5
2013	16.5	23.1	20.8	6.1	10.3	9.5	92.8	87.9	89.2	1.1	1.8	1.3
2014	14.8	21.7	21.6	6.5	10.6	11.3	92.5	87.7	86.0	1.0	1.7	2.7
2015	13.4	21.0	24.1	6.3	10.3	12.4	92.8	88.2	86.9	0.9	1.5	0.7
2016	12.6	19.6	24.5	6.6	10.5	10.8	92.4	88.1	88.4	1.0	1.5	0.8
2017	12.3	19.2	24.4	5.9	9.2	10.7	93.3	89.7	88.8	0.8	1.2	0.5
2018	11.5	18.1	24.2	5.9	8.0	8.9	93.5	91.1	90.5	0.7	0.9	0.6
2019	10.9	16.7	21.7	5.1	6.6	7.4	94.3	92.8	92.0	0.5	0.7	0.6

Notes: School Census (2007-2019). National Institute of Educational Studies (*Instituto Nacional de Pesquisas Educacionais*)/Ministry of Education. The Table shows indicators of schools managed by the municipal governments in Brazil.

Table B.2: Percentage of students found in the proficiency dataset, primary students (2010-2018)

	All			**Regular schools**			**Schools offering Acelera**		
	Second grade	Third grade	Fifth grade	Second grade	Third grade	Fifth grade	Second grade	Third grade	Fifth grade
2010		52.3	56.6	-	52.7	57.4	-	46.7	48.1
2011		53.7	69.1	-	54.5	70.3	-	51.4	65.5
2012		58.6	61.5	-	60.3	62.5	-	55.3	59.8
2013		21.0	53.0	-	22.7	54.4	-	17.2	50.1
2014		69.0	69.2	-	69.6	69.8	-	66.6	67.0
2015		58.6	59.7	-	60.2	60.6	-	55.0	57.8
2016	60.0		62.0	59.3	-	66.1	61.1	-	57.3
2017	75.4		79.1	77.0	-	85.7	73.7	-	73.3
2018	76.0		78.5	78.5	-	85.9	74.0	-	73.1
Total	70.7	52.2	65.2	70.9	53.7	66.1	70.4	47.5	63.5

Notes: EMPREL/Recife and SAEPE/Department of Education of Pernambuco. The Table schows the percentage of primary education students we were able to find in the proficiency dataset of the state of Pernambuco.

Table B.3: Descriptive statistics of Regular and *Acelera* schools (2010-2018)

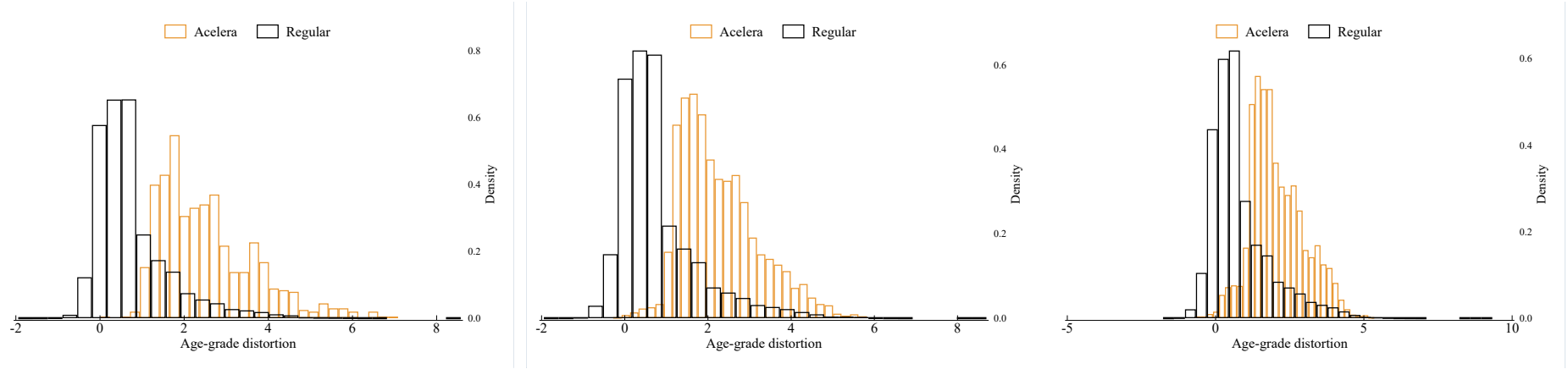
Difference	(1) Regular schools		(2) *Acelera* schools		T-test
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
Enrollments, first to fifth graders	1391	236.73	506	315.51	-78.78***
		(3.08)		(5.53)	
Age grade distortion year before, third grade - %	1280	24.10	500	31.33	-7.23***
		(0.30)		(0.48)	
Age grade distortion year before, fourh grade - %	1253	25.54	503	32.64	-7.10***
		(0.32)		(0.52)	
Age grade distortion year before, fifth grade - %	1245	26.58	500	32.22	-5.64***
		(0.30)		(0.50)	
Number of classrooms in the school	1153	8.21	326	10.14	-1.93***
		(0.10)		(0.21)	
Average proficiency Math year before, third grade	681	484.17	259	481.30	2.87
		(1.31)		(1.96)	
Average proficiency Portuguese year before, third grade	833	489.81	304	483.68	6.13***
		(1.24)		(1.83)	
Average proficiency Math year before, fifth grade	1061	190.80	485	190.37	0.43***
		(0.51)		(0.65)	
Average proficiency Portuguese year before, fifth grade	1061	182.85	485	183.09	-0.24***
		(0.50)		(0.71)	
Insufficient score Portuguese year before, third grade - %	681	76.19	259	76.72	-0.52
		(0.54)		(0.80)	
Insufficient score Math year before, fifth grade - %	833	52.80	304	55.91	-3.11***
		(0.57)		(0.83)	
Insufficient score Portuguese year before, fifth grade - %	1061	46.02	485	46.14	-0.11***
		(0.50)		(0.67)	
Insufficient score Math year before, fifth grade - %	1061	46.00	485	45.99	0.00***
		(0.51)		(0.70)	
Approval rate year before, first to fifth grade - %	1373	90.35	506	86.56	3.79***
		(0.14)		(0.26)	
Repetition rate year before, first to fifth grade - %	1373	8.34	506	11.96	-3.63***
		(0.13)		(0.25)	
Dropout rate year before, first to fifth grade - %	1373	1.31	506	1.48	-0.17***
		(0.05)		(0.10)	
Library - %	1153	46.92	326	69.33	-22.40***
		(1.47)		(2.56)	
Broad band internet - %	1121	92.42	310	92.90	-0.49
		(0.79)		(1.46)	
Computer Lab - %	1153	75.89	326	81.29	-5.40***
		(1.26)		(2.16)	
Science Lab - %	1153	2.78	326	3.07	-0.29
		(0.48)		(0.96)	
Number of classrooms available morning year before	1230	1.95	406	2.34	-0.39***
		(0.06)		(0.11)	
Number of classrooms available afternoon year before	1227	2.17	401	2.38	-0.21**
		(0.07)		(0.12)	

Notes: The value displayed for t-tests are the differences in the means across the groups. Fixed effects using variable year are included in all estimation regressions. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. The Table show descriptive statistics of schools offering only Regular Education and students that offered *Acelera* in at least one year between 2010-2018.

Table B.4: Balance test between fourth grade Acelera participants with proficiency available in fifth-grade (2010-2018)

	1		2		t-test
	Did not participate SAEPE 5th grade		Participated SAEPE 5th grade		Difference
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
Age-grade distortion, 4th grade	2828	2.36	464	2.12	0.24***
		[0.02]		[0.04]	
Approval rate, 4th grade	2523	88.74	465	86.02	2.72
		[0.63]		[1.61]	
Repetition rate, 4th grade	2523	8.60	465	13.76	-5.16
		[0.56]		[1.60]	
Performance in Portuguese, 3rd grade	1283	459.32	266	445.75	13.57***
		[2.54]		[5.58]	
Performance in Math, 3rd grade	1135	460.29	245	456.46	3.83*
		[2.58]		[5.70]	
If approved in 4th grade, jumped to 6th grade	2239	24.39	400	0.00	24.39***
		[0.91]		[0.00]	

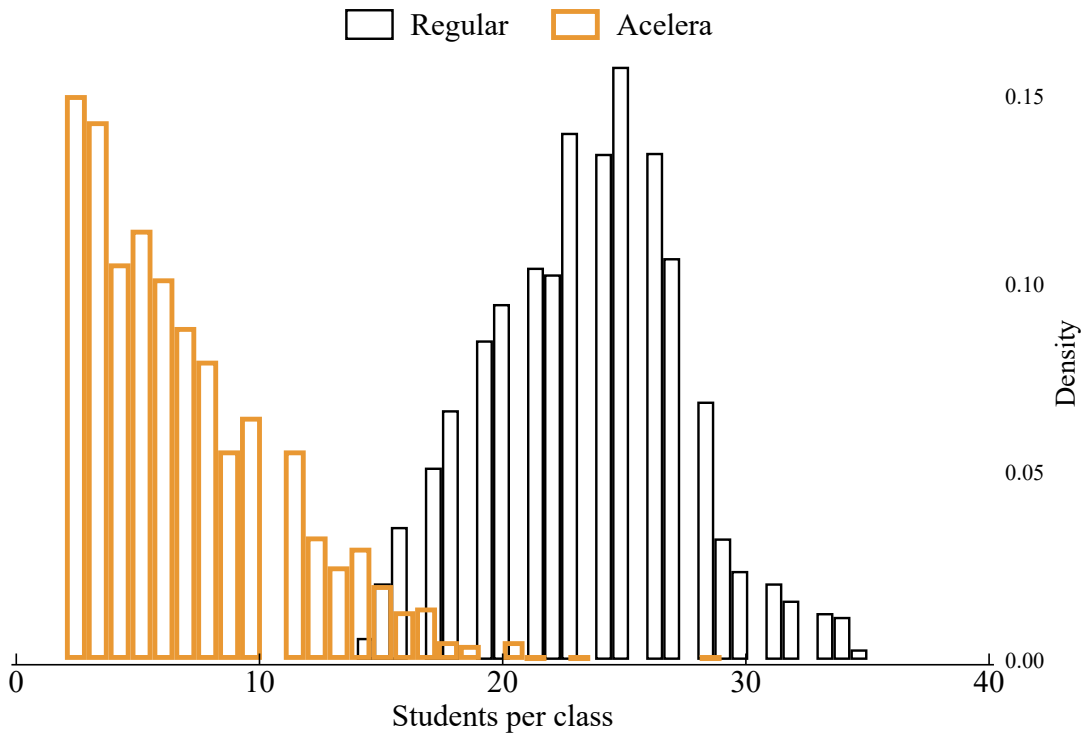
Figure B.1: Distribution of students with at least one year of age-grade distortion (2010-2018)



(a) Third-grade (b) Forth-grade (c) Fifty-grade

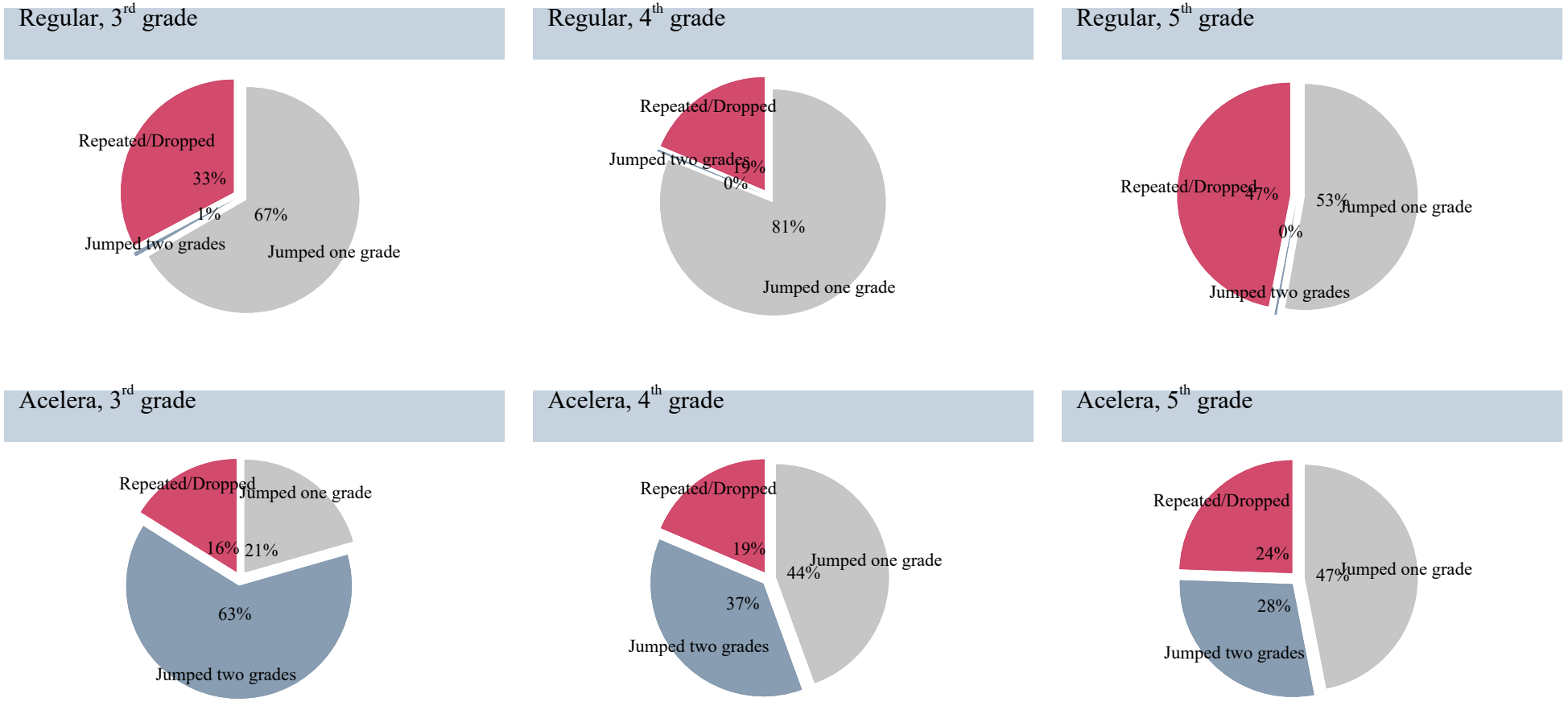
Note: Emprel/Recife. The Figures show the enrollment of students with at least one year of age-grade distortion in Regular Education and in *Acelera*.

Figure B.2: Distribution of students per class, third to fifth grade (2010-2018)



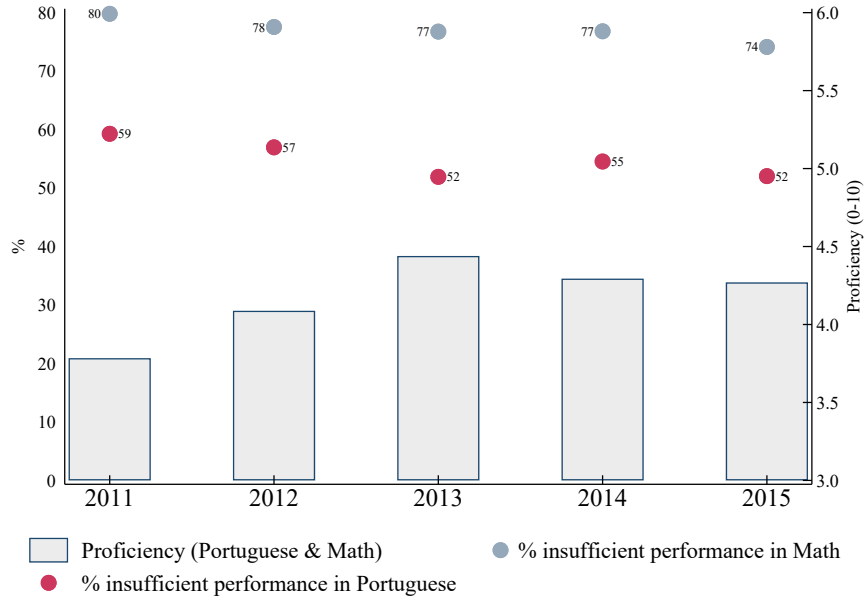
Note: EMPREL/Recife. The Figure shows the distribution of students per class in Regular Education and in *Acelera*. Data from third, forth and fifth grades.

Figure B.3: Approval, repetition and dropout rates of Regular Education and *Acelera*, third to fifth grade (2010-2014)

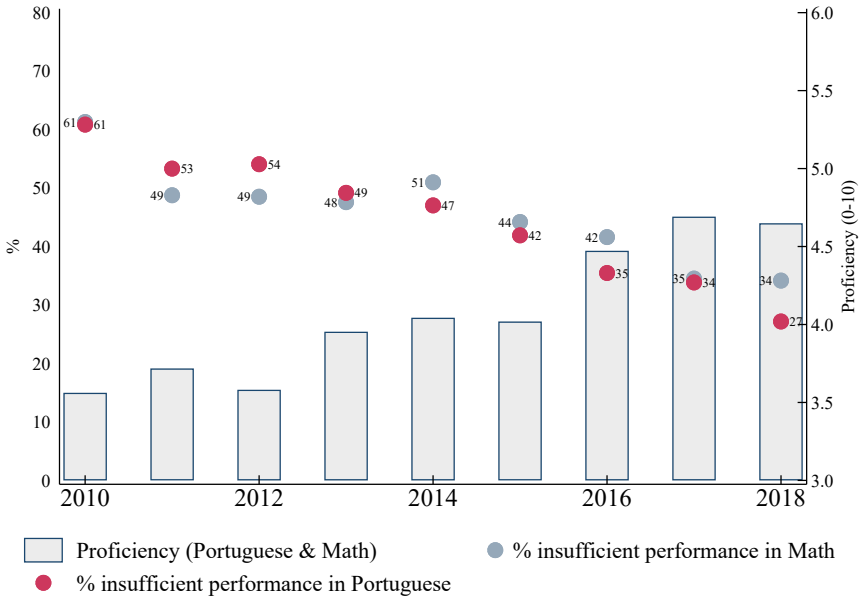


Note: Emprel/Recife. Dropout, approval and repetition rates of students with at least one year of age-grade distortion.

Figure B.4: Performance and percentage of students with insufficient performance (2010-2018)



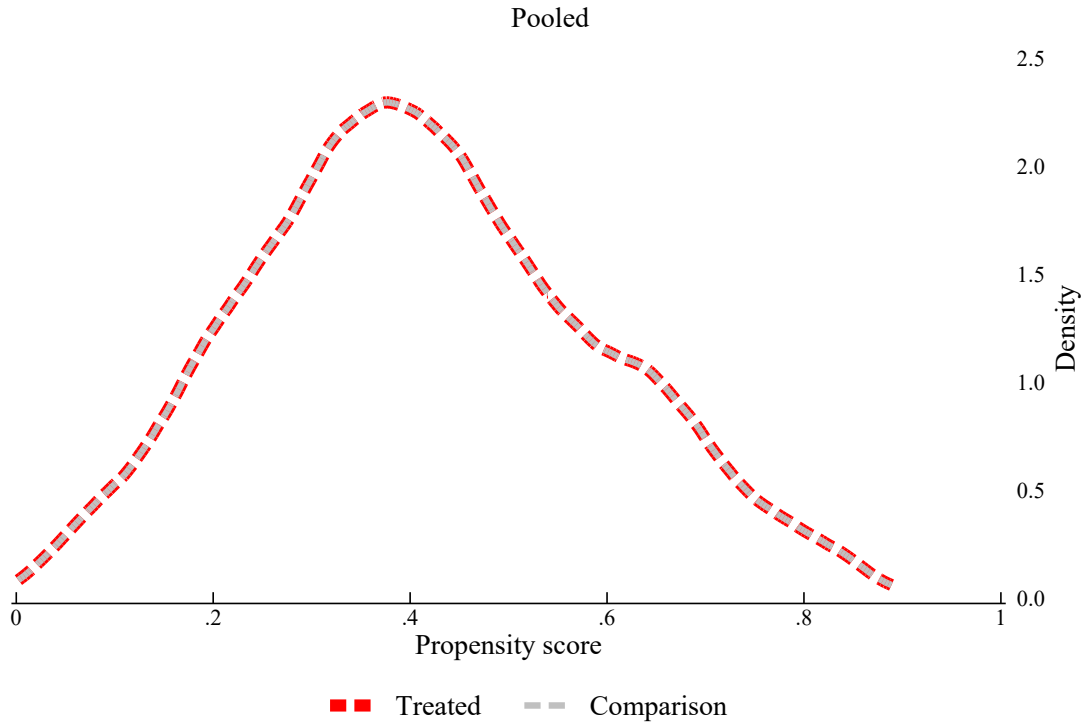
(a) Third-grade



(b) Fifth-grade

Note: SAEPE. The performance of third-graders is only available until 2015.

Figure B.5: Propensity score matching on the sample of schools offering *Acelera*, first to fifth grade (2010-2014)



Note: Authors' estimate. We matched students with at least one year of age-grade distortion that were enrolled in regular education and in *Acelera*. We used as controls: the age-grade distortion (in years), school, grade, gender, difference in years between the oldest and the youngest of the classroom the student is enrolled in, if the student was approved or not in the year before, and whether or not the student already participated of *Se Liga* (the intervention that aimed to teach children how to write and read that was also implemented in the municipality of Recife). The sample contains only data of schools that offered *Acelera* in at least one year between 2010 and 2014.

C Appendix to Chapter 3

Table C.1: Price deflator by geographical area

Geographical context	**Price deflator**
Metropolitan urban area of Belém	0.93
Urban North excluding metropolitan urban areas	0.94
Rural North	0.89
Metropolitan urban area of Fortaleza	0.90
Metropolitan urban area of Recife	0.89
Metropolitan urban area of Salvador	0.98
Urban Northeast excluding metropolitan urban areas	0.90
Rural Northeast	0.86
Metropolitan urban area of Belo Horizonte	1.03
Metropolitan urban area of Rio de Janeiro	0.96
Metropolitan urban area of São Paulo	1.00
Urban Southeast excluding metropolitan urban areas	0.96
Rural Southeast	0.92
Metropolitan urban area of Curitiba	0.95
Metropolitan urban area of Porto Alegre	1.00
Urban South excluding metropolitan urban areas	0.95
Rural South	0.82
Brasília	1.02
Urban Midwest excluding Brasília	1.01
Rural Midwest excluding Brasília	0.95

Source: Brazilian Expenditure Survey (POF) disclosed by Institute of Geography and Research (2008-2009).

Table C.2: Descriptive statistics of the inputs and outputs by municipality size

		Population size					
		Up to 5k	Between 5k and 50k	Between 50k and 100k	Between 100k and 500 k	More than 500k	Total, Brazil
2019 IDEB	mean	5.91	5.59	5.72	5.91	5.70	5.68
1st to 5th grade	sd	0.94	1.01	0.94	0.80	0.70	0.99
	min	3.30	2.30	3.60	3.60	3.90	2.30
	max	8.50	9.40	8.90	8.40	7.40	9.40
Expenditure per	mean	11,847	8,404	8,028	8,441	9,814	9,176
student in 2019	sd	4,557	2,459	2,222	2,292	3,728	3,385
	min	5,157	4,811	4,809	4,920	5,761	4,809
	max	75,711	23,840	17,210	18,877	28,408	75,711
Expenditure per	mean	11,587	8,069	7,704	8,083	9,502	8,858
student in 2018	sd	4,591	2,465	2,541	2,197	3,668	3,422
	min	4,749	4,581	4,582	4,655	5,508	4,581
	max	72,653	21,256	31,702	18,115	27,260	72,653
Expenditure per	mean	10,478	7,724	7,459	7,810	11,964	8,385
student in 2017	sd	3,868	2,049	1,862	1,893	12,739	3,163
	min	4,455	4,361	4,370	4,631	5,249	4,361
	max	56,255	22,325	12,241	16,785	103,862	103,862
Expenditure per	mean	10,729	7,794	7,347	7,707	9,578	8,449
student in 2016	sd	4,109	2,087	1,917	2,079	3,110	2,963
	min	5,181	4,632	4,634	4,621	5,038	4,621
	max	51,347	24,268	14,277	14,855	21,112	51,347
Expenditure per	mean	12,143	8,435	7,908	8,362	9,907	9,252
student in 2015	sd	6,291	2,957	2,440	2,394	3,138	4,223
	min	5,081	4,833	4,974	4,943	5,457	4,833
	max	85,104	46,084	19,737	18,825	20,842	85,104
2019 enrollments	mean	210	1,058	3,875	9,715	53,872	2,173
1st to 5th grade	sd	100	813	1,577	5,160	91,085	12,269
	min	11	56	913	1,683	1,635	11
	max	922	7,007	9,765	28,515	631,860	631,860
% of students'	mean	50.1	44.6	46.1	52.1	52.6	46.3
mothers	sd	17.3	13.8	10.2	9.0	9.0	14.4
with high school	min	0.0	0.0	20.8	22.0	35.5	0.0
	max	100.0	100.0	70.3	82.4	78.3	100.0

Source: The Education Development Index (IDEB) comes from the Education Assessment System (SAEB) disclosed by the National Institute of Educational Studies and Research (INEP). IDEB of schools managed by local authorities. The percentage of students' mothers with high school comes from the socioeconomic questionnaire of *Prova Brasil* applied by the INEP. The per-pupil expenditure is shown in 2020 BRL and comes from the Information System on Expenditures in Education (SIOPE). If refers to the expenditures made by the municipalities in their locally-managed schools. The average shown considers the difference in the cost of living in metropolitan, urban and rural areas.

Table C.3: Sample-size of the Brazilian municipalities included in the DEA

	Number of municipalities				Enrollments, first to fifth grade			
	Without exclusions	Excluding outliers Super-efficiency thresholds			Without exclusions	Excluding outliers Super-efficiency thresholds		
Number of inhabitants		1.3	1.2	1.1		1.3	1.2	1.1
Up to 5k	978	971	972	953	222,042	220,223	220,458	216,127
Between 5k and 50k	3,226	3,223	3,115	3,206	3,422,712	3,420,853	3,251,259	3,405,401
Between 50k and 100k	331	329	313	313	1,259,960	1,254,956	1,178,466	1,185,128
Between 100k and 500 k	253	250	237	243	2,445,813	2,428,771	2,292,848	2,381,263
More than 500k	45	41	43	38	1,966,815	1,855,385	1,843,008	1,786,192
Total, Brazil	4,833	4,814	4,680	4,753	9,317,342	9,180,188	8,786,039	8,974,111

Source: The number of Brazilian municipalities comes from the Institute of Geography and Research (IBGE). The enrollments are from Census of Education (2019) and include only schools managed by local authorities. The columns without exclusions show the number of municipalities before the exclusion of outliers in terms of efficiency scores achieved by their input-output combinations. The super-efficiency columns indicate the number of DMUs in the models that exclude outliers. The thresholds used are 1.5, 1.3, and 1.1. See Section **??**.

Table C.4: Number of benchmark DMUs by state

			Group Frontier		p8em Meta Frontier	
Brazilian region	State	N. municipalities	Benchmarks	%	Benchmarks	%
North	PA	91	18	19.8	11	12.1
Northeast	MA	171	22	12.9	15	8.8
North	AM	48	6	12.5	5	10.4
Northeast	CE	183	22	12.0	14	7.7
Northeast	AL	80	9	11.3	5	6.3
Southeast	ES	68	7	10.3	5	7.4
Southeast	RJ	82	8	9.8	3	3.7
Southeast	MG	756	53	7.0	30	4.0
Northeast	PE	178	12	6.7	5	2.8
Northeast	PI	193	13	6.7	9	4.7
Northeast	PB	198	11	5.6	6	3.0
North	AC	19	1	5.3	0	0.0
Northeast	SE	68	3	4.4	1	1.5
Northeast	RN	137	6	4.4	4	2.9
Southeast	SP	587	24	4.1	9	1.5
North	RO	50	2	4.0	2	4.0
South	PR	384	15	3.9	7	1.8
Midwest	GO	233	8	3.4	3	1.3
Northeast	BA	383	12	3.1	7	1.8
South	RS	333	8	2.4	4	1.2
South	SC	261	5	1.9	1	0.4
Midwest	MT	114	2	1.8	1	0.9
North	TO	122	1	0.8	1	0.8
Midwest	MS	73	0	0.0	0	0.0
North	AP	13	0	0.0	0	0.0
North	RR	8	0	0.0	0	0.0
Total	Brazil	4,833	268	5.5	148	3.1

Source: Authors' estimate for baseline specification.