# Spillover Effects of School Infrastructure Upgrade: Evidence from Peru

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**Abstract**

This paper studies a school infrastructure upgrading program and its direct and indirect effects on enrollment, school exit, and student achievement. We leverage the rollout of this policy in a span of 4 years before it was suddenly closed, leaving some selected schools without the program. We built on the school choice literature and create relevant markets to estimate our indirect effects. We find schools that benefit from the program see a reduction in dropout rates (0.57 p.p.). When looking at schools nearby, we find a positive effect on schools closing and negative effects on enrollment, mainly driven by private ones. Interestingly, we find that reading test scores nearby also decrease both in public and private suggesting that students who are leaving these schools might have been those with higher human capital.

**Keywords:** School Upgrading, Program Evaluation, Spillover Effects

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# 1 Introduction

Providing a supportive learning environment and facilitating effective teaching practices heavily rely on school infrastructure functionality. However, many schools in developing countries face major challenges due to a lack of facilities and resources. Therefore, several countries have launched school construction infrastructure upgrading (CITE XXXXXX). Even when there is mixed evidence about the effects of such policies (CITEXXXXXXXXXX), much less is known about the market effects that large investments can have on other schools, especially when there are higher levels of competition between low-cost private and public schools.

In this paper, we study the spillover effects of a school upgrading program in Peru. Interestingly, this program aimed not only to improve the infrastructure of these schools but also was part of a campaign to improve public schools' reputation, which at that time, had been losing enrollment due to quality concerns. This analysis is particularly relevant, given that private enrollment in Peru reaches up to 50 percent in large urban areas. We interpret this public infrastructure investment policy as a signal of increasing academic quality that can potentially increase public schools' attractiveness. In this sense, we examine how this policy can alter the private education sector's incentives regarding educational inputs.

In 2009, the Peruvian government created the Program for the Recovery of Emblematic and Centennial Public Educational Institutions[1] or Emblematic Schools Program, hereafter. This program aimed at refurbishing and upgrading the school infrastructure of several emblematic schools across the country. These schools were not selected in terms of school needs but rather because they are the oldest and used to have a higher reputation in the past. It is only after 2014, when the Ministry of Education, after closing the Emblematic Schools Program, when they decided to prioritize schools that actually required renovation or reconstruction.[2] The unexpected change of authorities and, therefore, the end of the Emblematic Schools Program provided us with a list of schools that were selected but did not get the program. These placebo schools form the basis of a difference-in-difference strategy. To causally estimate the effects of the Program, we leverage the staggered nature of the school upgrading and use the placebo schools as a never-treated control group.

[1] Programa Nacional de Recuperación de las Instituciones Públicas Educativas, Emblemáticas y Centenarias

[2] According to the Infrastructure Census of 2014, approximately, 70% of public schools nationwide needed infrastructure improvements, and 67% lacked essential services such as water, sewage, or electricity.

Our results suggest that XXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX add this at the end.

The paper speaks to four strands of the literature. First, we contribute to the extensive research investigating the relationship between educational spaces and student outcomes. This literature mainly uses as a source of exogeneity school construction or upgrading programs, or reforms increasing school funding to build and upgrade.[3] Studies on school construction programs have found positive effects on student achievement (Lafortune and Schönholzer, 2022; Kazianga et al., 2013, 2019; Burde and Linden, 2013), enrollment (Dinerstein et al., 2020; Kazianga et al., 2013; Burde and Linden, 2013), attendance (Kazianga et al., 2013), education attainment and future income (Duflo, 2001). With respect to upgrading school programs, there are positive effects on enrollment and decreasing dropout Adukia (2017). However, the effects on school achievement are mixed (Neilson and Zimmerman, 2014; Martorell et al., 2016; Cellini et al., 2010; Hong and Zimmer, 2016; Andrabi et al., 2023).[4] Currently, the main study evaluating improvements in school infrastructure in developing countries (Andrabi et al., 2023) does not disentangle if the gains in school achievement come from the infrastructure itself or other components of the intervention package. Our research adds to this literature by constituting the first study to analyze the direct effects of school infrastructure upgrading on student achievement in the context of a developing country.

A second strand of literature examines the market effects and spillovers of school improvements. The vast majority of studies analyze the spillover effects on housing prices or school zone composition (Cellini et al., 2010; Neilson and Zimmerman, 2014; Bayer et al., 2007; Black, 1999). Dinerstein and Smith (2021) examined an education reform that provided additional funding to public schools and found that this led to the exit of private schools (mainly low-quality ones) and an increase in dropout rates. Neilson and Zimmerman (2014) found no effects on competing schools context, and Andrabi et al. (2023) found a significant improvement in the standardized test scores of competing public and private schools,

[3] Building new schools and upgrading existing schools can lead to different outcomes: while creating new schools increases the number of available seats, upgrading allow students to enjoy more modern facilities, in the exact location and usually with the same teachers and staff (Lafortune and Schönholzer, 2022).

[4] School upgrading and equipping can lead to better academic performance through different channels (Cellini et al., 2010; Neilson and Zimmerman, 2014). On the student's side, it can reduce distractions, missed school days, and increase academic enthusiasm. On the teachers' side, it can affect teaching strategies, and improve morale, which in turn reduces absenteeism and turnover. Finally, it could also affect parents' involvement in their children's academic pursuits at home.

particularly those located closer to the treated schools. Dinerstein et al. (2020) studied a large construction program for public schools in the Dominican Republic, and found that it affected the private educational sector by generating a negative effect on enrollment, and an increase in school exit and dropout.

A third strand of literature examines the competition mechanism in generating market spillovers. From the school choice approach, the literature focuses on the effects generated in the educational market after the opening of charter schools on enrollment (Slungaard, 2022), attendance (Slungaard, 2022), suspensions (Slungaard, 2022; Rossetto and Aniceto, 2020), school performance (Slungaard, 2022; Ansari, 2021; Gilraine et al., 2021; Rossetto and Aniceto, 2020) and teacher salaries (Jackson, 2012). We contribute to this literature by showing that public school upgrading can change the educational market structure, even when there is no introduction of new competing schools.

Finally, this paper also speaks to the nascent literature that explores parental preferences for schools (Beuermann et al., 2022; Abdulkadiroğlu et al., 2020). We complement this literature by showing that improvements in school infrastructure can lead to changes in preferences for schools, as measured by revealed preferences. Parents may value school facilities more for the recreational opportunities or enhanced safety they provide, or simply because they are aesthetically more appealing (Cellini et al., 2010).

We study the direct and indirect effects of school infrastructure upgrading on enrollment, school exit and students achievement. Similarly to Dinerstein et al. (2020), we are able to evaluate the private school responses on the intensive and extensive margin. While Dinerstein et al. (2020) can only evaluate the effect on students' achievement at the market level, we can estimate these effects for the treated schools, and the private and public schools, separately.

The remainder of this paper is organized as follows: in section 2, I present the education setting in Peru and the upgrade infrastructure program. In section 3, I present the data. Sections 4 and 5 include the empirical strategy and descriptive statistics. Sections 6 and 7 present the main results of the paper and conclusion.

# 2 Background

## 2.1 The Peruvian Education Market

The Peruvian education system consists of two compulsory levels of basic education: elementary and secondary education. Elementary education is six years in length (grades 1 to 6), and ii) secondary education is five years in length (grades 7 to 11). This education system enrolls approximately 5.5 million students in these two levels, on average, every year (2015-2019). The elementary and secondary net enrollment ratio has remained above 97% and 80% in the last decade, respectively.[5]

Our study focuses on the urban education markets located in main cities. Urban areas contain 69.2% of the 30,907 existing private and public schools, which in turn account for 76.9% of the total enrollment. The capital, Metropolitan Lima, concentrates approximately 33.3% of this enrollment. Private schools are a key actor in the education market, specially in the urban areas.[6] They represent more than 25% of all the urban schools (Figure 1).[7] Private schools are for-profit organizations, and they tend to be smaller than the public schools. On average, their number of students enrolled per grade accounts for only 6.9% of the total enrollment in a public school. Private schools are not subsidized via vouchers and their tuition fees translate one-to-one to out-of-pocket expenses for parents.

The administration of the public and private education systems differs. While the public education system relies on MINEDU as administrator, the private education sector is unregulated and lacks oversight mechanisms (Balarin and Escudero, 2019). MINEDU retains primary responsibility for funding, determining school calendars, setting the national curriculum, and designing and distributing textbooks in public schools. More importantly, since 2013 MINEDU monitors teacher training, establishes salary schedules for teachers, and implement a centralized application system for teacher assignment and tenure-track teacher contracts (with higher salaries based on tenure and performance).[8] In contrast, private school can take independent decision on how to operate and organize the school.

[5] World Bank Open Data.

[6] The percentage of the total number of private schools nationwide that are located in urban areas is 91.6%.

[7] Several qualitative studies have analyzed the factors driving rise of private enrollment in the country (Balarin, 2015; Cuenca, 2013; Cuenca et al., 2019; Roman and Ramirez, 2018; Sanz, 2014). These studies find that the main factor is the perception that private schools offer better quality education than public schools. Additionally, families perceive that private education enhances social status and provides better opportunities for higher education.

[8] For more detail, see *Law for the Teachers' Payment Reform* (Law N° 29944 and its regulations).

**Figure 1:** Evolution of enrollment and public enrollment share


Moreover, teachers in private schools do not need to meet any certification requirement and are only subject to labor laws for private employers.[9] As a result, private schools are highly heterogeneous, with low-cost and low-quality schools to high-performance and high-cost schools. Low-cost schools account for approximately 63% of the private enrollment. Additionally, this lack of regulation allowed for the proliferation of informal and illegal schools.

## 2.2 The School Upgrading Program

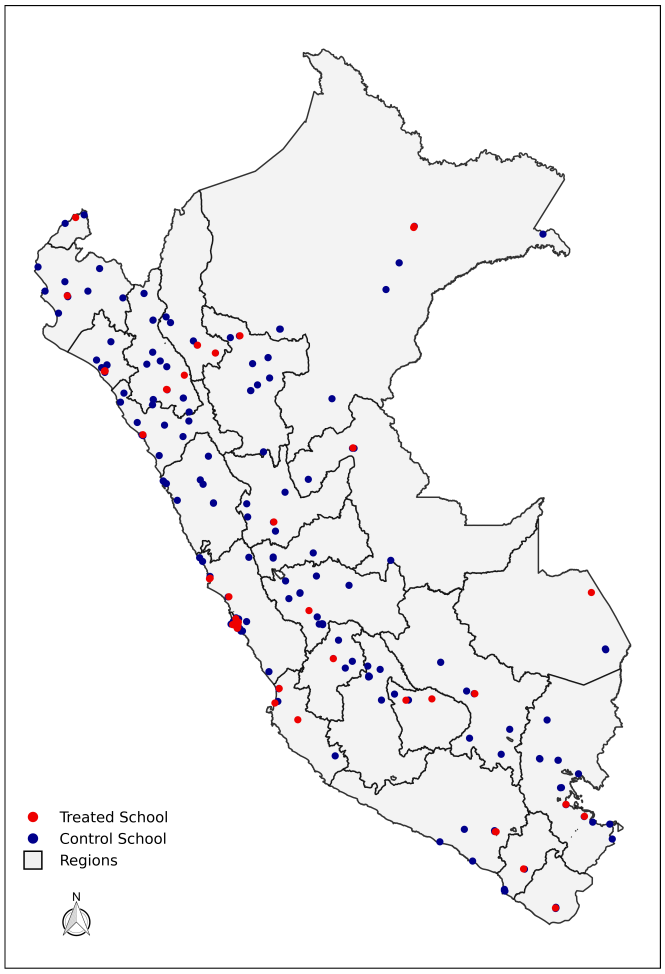
The Emblematic Schools Program was established in 2009 to refurbish, renovate, and equip priority existing schools at the primary and secondary levels (Saavedra and Gutierrez, 2020).[10] This program did not to increase the capacity of the school, but replaced and refurbished the existing classrooms, and renovated or built new auxiliary areas (e.g., sports

[9]The origin of this lack of regulation of the private sector lies in the 1996 reform that liberalized the education market (Legislative Decree N° 882 - *Law for the Promotion of Private Investments in Education*). In 1989, 88.7% of schools were public, and the existing deficit of classrooms amounted to 40,000 (Mujica et al., 1992). Through the Law N° 882, the government aimed to promote the private investment in the education sector with the aim to modernize the educational system and expand the enrollment coverage. For this purpose, the government lowered the market entry barriers by providing tax incentives for private schools (credit for 30% of the reinvested utilities) and tax exemptions for importing and sales (Allende, 2019).

[10]See Urgent Decree N° 004-2009 - *Creation of the National Program for the Recovery of Emblematic and Centenary Public Schools*

fields, laboratories, teacher areas, etc.).[11] The program prioritized schools that had an outstanding historical trajectory, served many students, and were in middle income areas (MINEDU, 2013). In the beginning, the Program consisted of 20 schools in Metropolitan Lima, but by the middle of 2011, it had expanded to include 238 schools. These schools are nationwide, with 74.8% of them located in main cities and 20.6% in Metropolitan Lima (Figure 2). There are 71.5% of participating schools that offer both primary and secondary education, 24.3% offer only secondary education, and 4.2% offer only primary education.

**Figure 2:** Spatial distribution of the 238 Emblematic Schools




Note: The map shows the spatial distribution of the 238 educational institutions incorporated into the Emblematic Schools Program, classified according to whether they are treated or control schools as of 2014.

[11] Officials from the MINEDU indicate that, before 2015, every emblematic school would receive a standardized package of auxiliary areas, which was determined by the central government. Since 2015, the package of auxiliary areas would vary by school, in response to particular needs and population's demand.

The Emblematic Schools Program closed in January 2013,[12] due to the finding of irregularities and corruption.[13] From 2013 to 2014, the infrastructure office of MINEDU (OINFE) took over the ongoing and new upgrading projects. During the OINFE administration, only 3 new Emblematic schools were implemented. In late 2014, the National Education Infrastructure Program (PRONIED) was created [14] and took over the remaining projects since 2015. PRONIED share the objective from the Emblematic Schools Program;[15] however, it does not limit its actions to the 238 Emblematic Schools. Instead, it prioritizes poor schools with high infrastructure deficits. In addition, the selection of treated schools is coordinated with local governments and can respond to local population's demand. These changes caused that several schools originally planned to be upgraded were not treated.

This study focuses on the period between 2009 and 2014, when only the Emblematic Schools were being treated and no other educational policies were in place. By 2014, only 93 schools had completed their first infrastructure investment project. Among these schools, 74.6% had both primary and secondary education, 24.9% had only secondary education, and 0.6% had only primary education. An annual average of 15 Emblematic schools were treated (Figure 3). The Emblematic Schools Program implemented multiple infrastructure upgrade projects, the most common being the construction or renovation of restrooms, classrooms, sports facilities, outdoor areas, and administrative spaces. On average, each school had 9 infrastructure upgrade projects and received a total investment of 1.5 million USD.[16] The first project was completed in approximately 1.2 years, on average.

[12] See Supreme Decree No. 018-2012-ED

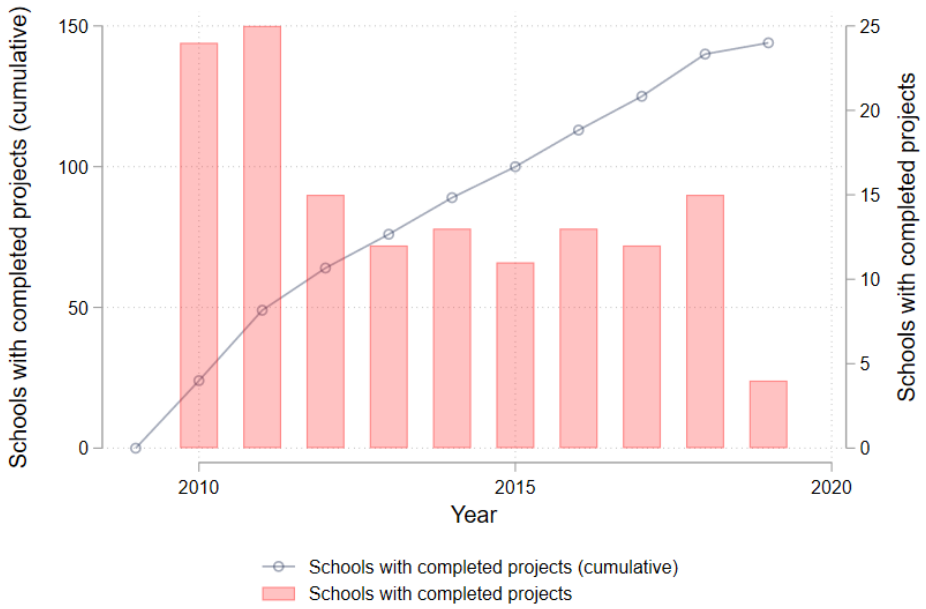
[13] In September 2011, the recently elected administration opened an investigation. Their findings indicate that, by 2011, only 21.8% of the physical investment had been realized with the full use of financial resources. Additionally, there was evidence of collusion between private companies and central government officials. More details can be found here.

[14] Supreme Decree N.° 001-2014-MINEDU - *Ministry of Education*

[15] In addition to refurbishing, renovating, and equipping schools, this program also includes school maintenance activities. This Program also develops activities in higher education institutions.

[16] AQUI PONER EN PERSPECTIVA ESTE MONTO CONTANDO CUANTO SE INVIERTE EN LA RENOVACION DE COLEGIOS NO EMBLEMATICOS POR PRONIED

**Figure 3:** Number of emblematic schools with completed project




# 3 Data

## 3.1 Program Administrative Records

We use administrative data from the Emblematic Schools Program to obtain the final list of selected schools (238 schools). Additionally, we have information regarding the progress of each infrastructure investment project, their starting and ending dates, and the number of students benefiting from this program. This allows us to determine the precise moment when the schools are treated. We also have information on the exact characteristics of the renovations, refurbishing, and equipping from the projects' technical documentation.

## 3.2 Educational data

This study relies on 2 primary educational data sources: the School Census (CE), and the Student Census Evaluation (ECE).

- The **School Census** (2006 - 2014) contains school-level data on enrollment by gender, age, and grade; the number of teachers by gender, grade, level of education attained, and type of contract; students' academic results (i.e. approved, dropped out, and transferred). It also includes self-reported data on school facilities, infrastructure and

furniture. Our main outcomes are school enrollment and students' achievement. The information on teacher composition and school infrastructure allow us to analyze how schools adjust their educational inputs when they are directly or indirectly exposed to infrastructure upgrading. More importantly, the Census contains information on the addresses of public and private schools nationwide. We geocoded each institution since this information is crucial for defining the relevant market for each Emblematic School.

- The **Student Census Evaluation** (2007 – 2014) provides individual-level results on standardized test scores in mathematics and language for 2nd graders. All private and public schools with more than five 2nd-grade students should take this test. These results do not condition or relate to grades obtained in school.

# 4 Methodology

In this paper, we focus on the early stages of the program between 2009 and 2014, before it was closed down. This includes 238 schools listed in Emblematic Schools Program. We implement a difference-in-difference strategy with staggered treatment, given the gradual way these investments were implemented over time due to budget restrictions. Furthermore, the closing of the program due to major corruption issues in the central governments allowed us to have a group of schools that should have been treated but were not.

An advantage of this strategy is that it does not require random assignment to the treatment group. However, a threat to our empirical strategy is whether the opening of the renovated schools is correlated with other shocks to the dependent variables we are analyzing. From discussions with Ministry of Education officials, we are aware that any additional programs for those schools did not accompany the implementation of the Program.

First, to evaluate the direct effects of the Program on the treated schools, we will estimate the difference-in-difference model at the school level as follows:

$$y_{st} = \delta_s + \gamma_t + \beta 1[PCE_s \times Post_t] + \varepsilon_{st} \tag{1}$$

Where $y_{st}$ is the variable of interest at school level $s$ in period $t$. Our variables of interest are school exit, enrollment, student's achievement measured (measured by standardized tests and schools' academic results), and the school's educational inputs: teaching staff and school's infrastructure. $\beta$ is the coefficient of interest (ATT). $1[PCE_s \times Post_t]$ is the indicator function that takes the value of 1 when the Program is active in school $s$. $\delta_s$ y $\gamma_t$ are the school and year fixed effects, respectively. $\varepsilon_{st}$ is the error term. We will employ the event study technique to visualize the dynamic results and show the treatment effects before treatment to validate the assumption of parallel trends. For this estimation, we will rely on the Borusyak et al. (2021) estimator, which is robust to heterogeneous and dynamic treatment effects for the staggered treatment.

To evaluate the indirect effects of the Program, we expand our sample to include nearby schools located in the neighborhood of the participating emblematic schools. First, we define the relevant markets of the 238 eligible schools for the Program. A relevant market is defined as a market that includes all schools among which there is close competition or which, from the consumer's perspective, are close substitutes. Following previous literature, we determine the relevant market using a distance criterion (Dinerstein et al., 2020; Allende, 2019; Ansari, 2021; Slungaard, 2022). The relevant market of the program-eligible schools will be those located in a 2km buffer,[17] but other distances will be explored as a robustness check. This definition assumes that competing schools are located geographically close together and that students typically choose schools close to them.

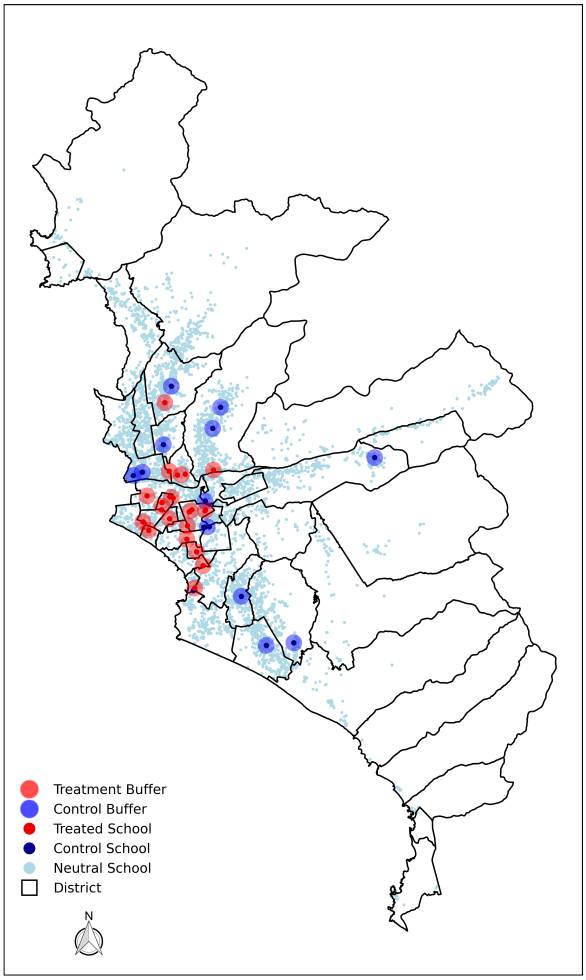
Figure 4 shows a graphical example of how the relevant markets are built for Lima, considering a 2km distance. Our final sample includes X relevant markets, each of them containing an average of X competing schools.[18] The treatment assignment is at market level. Those schools that are located around the upgraded emblematic schools are the treated competing schools within their respective relevant market; while those schools that are nearby the control emblematic schools are part of the control competing schools.

For the analysis of the spillover effects, the econometric specification is as follows:

[17] Using the Encuesta Nacional de Programas Presupuestales (ENAPRES), which contains questions related to the time (in minutes) it takes a student to get from home to school, we estimate that a student travels on average 0.82 kilometers on foot, 2.23 kilometers by bicycle, 3.83 kilometers by motorcycle, 4.56 kilometers by car, and 4.28 kilometers by bus. For the calculation of these measures, we based speed assumptions on kilometers per hour taken from Velásquez (2023). Accinelli (2018) determines that in low-income areas of Lima the primary education market is highly competitive, and the school market size is 1km. Allende (2019) indicates that the average distance between the family's location and the chosen school is 3km in Peru.

[18] Since we explore the competition channel between schools, we restrict the sample to relevant markets composed of at least five competing schools. Only X relevant markets are left out of the analysis.

**Figure 4:** Relevant markets in Metropolitan Lima (2km)




$$y_{jmt} = \eta_j + \tau_t + \theta 1[PCE_{jm} \times Post_t] + \mu_{jmt} \tag{2}$$

This specification is similar to (1), with the difference that $1[PCE_{jm} \times Post_t]$ is the indicator function that takes the value of 1 when the emblematic school in the relevant market $m$ is treated. In other words, the indicator function takes the value of 1 when the competing school $j$ in the relevant market $m$ is indirectly exposed to the Emblematic School Program (i.e. a emblematic school is treated). $\theta$ is the coefficient of interest.

# 5 Descriptive Statistics

Table 1 shows the summary statistics for the three analyzed samples for the period before the school upgrading program started (2006 - 2009): i) the emblematic schools, ii) the competing private schools, and iii) the competing public schools. Panel A shows the percentage of schools that exit the market and the average yearly enrollment. As we can see, the competing private schools are more likely to leave the market and are smaller in enrollment. While the average enrollment in these private schools is 81 students, the enrollment in the emblematic and competing public schools is 1,065 and 270, respectively.

**Table 1:** Descriptive statistics

| | Emblematic schools (1) | | | Competing private schools (2) | | | Competing public schools (3) | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | n | Mean | SD |
| Panel A. ***School exit*** | | | | | | | | | |
| School exit | 1504 | 0.01 | 0.09 | 58390 | 0.23 | 0.42 | 54466 | 0.03 | 0.18 |
| Total enrollment | 1504 | 1064.80 | 675.78 | 58390 | 80.84 | 123.87 | 54466 | 269.91 | 292.38 |
| Panel B. ***Student's academic outcomes*** | | | | | | | | | |
| Approved (%) | 1482 | 87.76 | 8.20 | 42831 | 95.54 | 8.24 | 51846 | 85.80 | 9.91 |
| Dropout (%) | 1482 | 3.92 | 3.23 | 42831 | 2.39 | 5.29 | 51846 | 6.55 | 6.51 |
| Panel C. ***Standardized tests*** | | | | | | | | | |
| Math z-score | 407 | 0.26 | 0.83 | 16559 | 0.24 | 0.87 | 20932 | -0.20 | 1.06 |
| Reading z-score | 408 | 0.23 | 0.77 | 16543 | 0.50 | 0.80 | 20939 | -0.40 | 0.97 |
| Panel D. ***Teacher variables*** | | | | | | | | | |
| Number of teachers | 1463 | 18.19 | 25.45 | 37977 | 7.76 | 8.57 | 50349 | 8.97 | 11.97 |
| Number of students per teacher | 1463 | 270.10 | 393.44 | 37977 | 33.45 | 64.46 | 50349 | 89.96 | 154.23 |
| Female (%) | 1463 | 51.58 | 30.83 | 37977 | 53.07 | 33.72 | 50349 | 50.36 | 33.15 |
| Teachers with higher education (%) | 1016 | 99.53 | 4.78 | 29867 | 99.66 | 3.90 | 33582 | 99.42 | 5.66 |
| Teachers with tenure (%) | 1268 | 70.80 | 36.00 | 32754 | 31.45 | 41.54 | 41868 | 67.20 | 40.08 |
| Teachers with management positions (%) | 1463 | 23.64 | 33.69 | 37977 | 22.75 | 34.00 | 50349 | 30.15 | 35.59 |
| Panel E. ***Infrastructure variables*** | | | | | | | | | |
| Access to basic services | 1476 | 0.93 | 0.25 | 42366 | 0.89 | 0.31 | 51912 | 0.54 | 0.50 |
| Number of clasrooms | 1473 | 33.60 | 15.26 | 42237 | 11.57 | 7.90 | 51820 | 11.85 | 8.45 |
| Clasrooms in good condition (%) | 1473 | 50.90 | 36.98 | 42217 | 94.90 | 17.36 | 51812 | 49.29 | 38.78 |
| Has teacher rooms | 1477 | 0.65 | 0.48 | 42442 | 0.57 | 0.49 | 51943 | 0.26 | 0.44 |
| Has library | 1477 | 0.89 | 0.32 | 42401 | 0.55 | 0.50 | 51900 | 0.52 | 0.50 |
| Has laboratory | 1480 | 0.69 | 0.46 | 42570 | 0.24 | 0.43 | 51964 | 0.22 | 0.42 |
| Has auditorium | 340 | 0.47 | 0.50 | 10012 | 0.20 | 0.40 | 12267 | 0.14 | 0.35 |
| Has administrative building | 1475 | 0.89 | 0.31 | 42333 | 0.87 | 0.34 | 51902 | 0.60 | 0.49 |

**Note:** The table shows descriptive statistics for enrollment, school exit, academic results, teacher variables and educational infrastructure for public schools, private schools and the emblematic schools. The period of analysis is between 2006-2009. Test scores correspond to 2nd graders and are standardized into z-scores based on yearly averages and standard deviations. The Access to basic services variable is a dummy that takes the value of 1 when the school has access to piped water, electricity and sanitation services.

On Panel B, we observe the student's academic outcomes. Private schools have higher approval rates (96%) than the public sector. The dropout rate is 7% in the traditional public schools, and lower in the emblematic and private schools (4 and 2%, respectively). Panel C shows the z-scores in the standardized tests in math and reading for 2nd graders. The emblematic and private schools have similar average math scores (approximately 0.25 sd), while the traditional public schools have an average of -0.20 sd. In terms of reading scores, the private schools show the highest scores (0.5 sd), followed by the emblematic schools (0.26 sd) and the traditional public schools (-0.2 sd).

Panel D shows the teacher's characteristics. The number of teachers at emblematic schools is double the number of teachers in the private and traditional public schools. The percentage of female teachers is close to 50% in all samples. Almost all teachers have higher education studies. The percentage of teachers with long-term contracts or tenure is higher in public schools. Finally, teachers in the traditional public schools are more likely to assume additional managerial roles at schools. Panel E shows the infrastructure variables. The emblematic schools have the highest access to the basic services of water, electricity, and sanitation (92%), followed by the private schools (84%) and the traditional public schools (53%). The emblematic schools have three times more classrooms than the private and traditional schools. However, private school classrooms have better conditions.

The balance tables are in the Appendix (Tables A.1, A.2 and A.3). These tables show the balance test for the treated and control schools during the period before the Program (2006 - 2009). Table A.1 shows that the treated emblematic schools are bigger in terms of enrollment and size of infrastructure but equal in all other characteristics. Table A.2 shows that the private treated schools have larger enrollment, and higher student's scores in both math and reading standardized tests. There are also differences in the teaching staff and infrastructure; however, these differences are economically trivial. Finally, Table A.3 also shows small but significant differences between treated and control schools in terms of infrastructure and teaching staff. While these results are reassuring, it is worth noting that our identification strategy does not require balance between treatment and control schools at baseline. Instead, it relies on the assumption of parallel trends, which we investigate graphically later.

# 6 Results

## 6.1 Direct effects on the Emblematic Schools

### 6.1.1 Effect on Enrollment

In Table 2 we show the estimates for the aggregate effect of school upgrading program on enrollment. There are no aggregate impacts on enrollment. This is consistent with the fact that the program did not aim to increase school capacity. Figure A.1 shows the corresponding event study plot. We see a negative trend in the pre-period and a negative effect on enrollment in the year when the upgraded school starts full operation. We do not interpret this as a violation of the parallel trends. These negative effects are consistent with the fact that the emblematic schools do not close entirely, but create temporary classrooms to maintain most of their students enrolled during the upgrading process. The finding of significant negative effects on the previous two years before the emblematic school upgrading is finalized is consistent with the 2 years that the infrastructure upgrading work takes on average. Enrollment returns to levels previous to the beginning of the upgrading work after the first year of infrastructure upgrading completion.

**Table 2:** Direct effects on enrollment

| | Total enrollment | Total enrollment (log) |
|---|---|---|
| | (1) | (2) |
| Treat*Open | -18.727 | 0.008 |
| | (27.807) | (0.068) |
| Dep. Var. Mean | 1086.535 | 7.426 |
| Observations | 1,665 | 1,665 |
| School FE | Yes | Yes |
| Year FE | Yes | Yes |

Standard errors in parentheses. Errors clustered at the relevant market level. $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

### 6.1.2 Effect on Student's Achievement

Table 3 shows the aggregate effects on school academic outcomes and the standardized tests in math and reading for second graders. There is no effect on passing rates; however, the dropout rate decreased by 0.57 percentage points. Figure A.2 shows the corresponding event study plots on the approval and dropout rate. The trends in dropout are fairly flat in

the pre-period and show a significant reduction in treated schools in years 3 and 4 after the upgrading program was put in place. The event plot for the approval rate is particularly noisy. We find no effects on the achievement on standardized tests in reading and math (Table 3).[19] However, these results may be a limited measure of academic outcomes for the emblematic schools, as improvements in school facilities may have greater effects in other subjects such as science, where laboratories, for instance, can make an important contribution (Cellini et al., 2010).

**Table 3:** Direct Effects on Student's Achievement

| | Approved (%) | Dropout (%) | Reading z-score | Math z-score |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Treat*Open | 0.771 | -0.574** | -0.010 | 0.042 |
| | (0.586) | (0.264) | (0.071) | (0.109) |
| Dep. Var. Mean | 86.758 | 3.346 | 0.349 | 0.449 |
| Observations | 1,647 | 1,647 | 497 | 496 |
| School FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |

Standard errors in parentheses. Errors clustered at the relevant market level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

## 6.2 Spillover Effects

In this section we explore the spillover effects that the school upgrading program had on the nearby competing schools located 2km around the emblematic schools. In a similar manner to the previous section, we explore the outcomes of enrollment and student achievement; however, we add the outcome of school exit.

### 6.2.1 Spillover Effect on School Exit and Enrollment

Table 4 shows the indirect effects on school exit and enrollment. Panel A shows the jointly effect on private and public competing schools, while Panel B and C estimate these effects separately. From Column 1, we see that having an upgraded emblematic school makes surrounding schools more likely to close. In aggregate terms, we see that the cumulative exit rate increase by 4.1 p.p. This effect is more pronounced for private schools (6 p.p.), than for public schools (1.4 p.p.). These magnitudes are similar to the effects (5 p.p.) in the

[19] Unfortunately, we cannot estimate the dynamic effects for the standardized test scores.

increase in the private school exit rate when a new public school opens in the Dominican Republic (Dinerstein et al., 2020). From Figure A.3, we also see that the private schools react faster than the public schools. The effect on private school exit starts immediately after the emblematic schools are treated, while the public schools basically react since year 3.

Columns 2 and 3 from Table 4 show the result on enrollment in levels and logs. We found that there is a negative and significant effect on enrollment in the traditional public schools. These schools lose 57 students once the upgraded emblematic schools started operating. Private schools are also losing students, although this effect is not statistically significant. We found no evidence of a violation of parallel trends for any of the variables for either the public or private sector (Figure A.3).

**Table 4:** Spillover Effects on School Exit and Enrollment

| | School exit | Unconditional Enrollment | Conditional Enrollment | Unconditional Log(Enrollment) | Conditional Log(Enrollment) |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Panel A. ***Total schools nearby*** | | | | | |
| Treat*Open | 0.041** | -3.331 | -3.260 | -0.090 | -0.054*** |
| | (0.020) | (2.577) | (2.514) | (0.058) | (0.020) |
| Dep. Var. Mean | 0.122 | 228.532 | 261.578 | 4.799 | 5.461 |
| Observations | 81538 | 92286 | 80383 | 92286 | 80383 |
| School FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Panel B. ***Private schools nearby*** | | | | | |
| Treat*Open | 0.060** | -1.931 | -1.769 | -0.135* | -0.070*** |
| | (0.026) | (1.969) | (1.725) | (0.078) | (0.026) |
| Dep. Var. Mean | 0.167 | 102.048 | 122.768 | 4.082 | 4.885 |
| Observations | 56876 | 64686 | 53258 | 64686 | 53258 |
| School FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Panel C. ***Public schools nearby*** | | | | | |
| Treat*Open | 0.014*** | -26.221*** | -25.675*** | -0.133*** | -0.115*** |
| | (0.004) | (7.162) | (7.069) | (0.033) | (0.025) |
| Dep. Var. Mean | 0.020 | 457.970 | 466.775 | 6.359 | 6.479 |
| Observations | 21659 | 24265 | 23805 | 24265 | 23805 |
| School FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |

Standard errors in parentheses. Errors clustered at the relevant market level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

### 6.2.2 Spillover Effects on Student's Achievement

Table 5 shows the spillover effects on the approval and dropout rate, and the results on the standardized tests on reading and math from second graders. From Column 1, we see that the approval rate in private schools increased by 0.67 p.p., while it decreased by 0.56 p.p. in

the public schools. Since these affects have contrary effects, the aggregate effect on approval rate is null. We do not find effects on dropout (Column 2). There is a significant reduction in the scores 2nd grade students get in the reading standardized test in the private and public competing schools. This negative effect is bigger in the public schools (0.057 sd) than in the private schools (0.038 sd). There are no effects on math.

In Figures A.4 and A.5, we assess the assumption of parallel trends for the sample of private and public schools, respectively. We find no evidence of a violation of parallel trends.

**Table 5:** Spillover effects on Student's Achievement

| | Approved (%) | Dropout (%) | Reading z-score | Math z-score |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Panel A. ***Total schools nearby*** | | | | |
| Treat*Open | 0.149 | -0.036 | -0.057*** | -0.038 |
| | (0.219) | (0.123) | (0.020) | (0.031) |
| Dep. Var. Mean | 92 | 3 | 0 | 0 |
| Observations | 78,969 | 78,969 | 37,291 | 37,298 |
| School FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Panel B. ***Private schools nearby*** | | | | |
| Treat*Open | 0.673** | -0.190 | -0.038** | -0.002 |
| | (0.271) | (0.139) | (0.019) | (0.030) |
| Dep. Var. Mean | 94 | 2 | 1 | 0 |
| Observations | 52,060 | 52,060 | 23,045 | 23,058 |
| School FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Panel C. ***Public schools nearby*** | | | | |
| Treat*Open | -0.564** | 0.090 | -0.057** | -0.024 |
| | (0.259) | (0.156) | (0.029) | (0.044) |
| Dep. Var. Mean | 87 | 4 | 0 | 0 |
| Observations | 23,610 | 23,610 | 13,135 | 13,130 |
| School FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |

Standard errors in parentheses. Errors clustered at the relevant market level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

# 7 Conclusions

In this paper, we examined the direct and spillover effects of a national school infrastructure upgrade program in Peru. Using a staggered difference in difference strategy, we found the upgrade in the emblematic public schools generated a reduction in the dropout rate by 0.57 percentage points, but no effects on student's achievement. The upgrade of these schools produced market effects. The start of operations of the upgraded emblematic school exerted competitive pressure that provoke some competing schools to leave the market. This effect is bigger for private schools (6 p.p.) than for public schools (1.4 p.p.). The public schools that remained opened the enrollment had a reduction in total enrollment. There is a negative effect on the reading standardized test for second graders.

Future drafts will incorporate heterogeneous treatment effects in the event study analysis, robustness checks, and explore that mechanisms that can explain the observed results. Specifically, we will explore how the competing schools modify their educational inputs such as teaching staff and school infrastructure.

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# A Additional Figures and Tables

**Table A.1:** Balance table for the emblematic schools

| | Control (1) | | | Treatment (2) | | | T-test (2)-(1) |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | Diff |
| Panel A. ***School outcomes*** | | | | | | | |
| School exit | 944 | 0.01 | 0.09 | 540 | 0.01 | 0.09 | -0.000 |
| Total enrollment | 944 | 945.52 | 612.25 | 540 | 1274.45 | 733.22 | 328.928*** |
| Panel B. ***Student academic results*** | | | | | | | |
| Approved (%) | 928 | 87.84 | 7.78 | 534 | 87.53 | 8.96 | -0.307 |
| Dropout (%) | 928 | 4.03 | 3.02 | 534 | 3.76 | 3.59 | -0.271 |
| Panel C. ***Standardized tests*** | | | | | | | |
| Math z-score | 257 | 0.25 | 0.86 | 144 | 0.28 | 0.79 | 0.033 |
| Reading z-score | 257 | 0.15 | 0.82 | 145 | 0.35 | 0.67 | 0.204 |
| Panel D. ***Teaching Staff*** | | | | | | | |
| Number of teachers | 911 | 16.81 | 25.64 | 532 | 19.66 | 23.28 | 2.852 |
| Number of students per teacher | 911 | 272.71 | 383.72 | 532 | 267.94 | 411.91 | -4.773 |
| Female (%) | 911 | 50.90 | 31.06 | 532 | 52.84 | 30.47 | 1.944 |
| Teachers with higher education (%) | 618 | 99.45 | 5.88 | 384 | 99.66 | 2.18 | 0.211 |
| Teachers with tenure (%) | 776 | 70.22 | 36.76 | 476 | 71.21 | 35.08 | 0.996 |
| Teachers with management positions (%) | 911 | 26.72 | 34.61 | 532 | 18.44 | 31.16 | -8.280** |
| Panel E. ***Infrastructure variables*** | | | | | | | |
| Access to basic services | 937 | 0.92 | 0.27 | 536 | 0.93 | 0.26 | 0.009 |
| Number of classrooms | 937 | 29.61 | 13.50 | 536 | 39.00 | 17.30 | 9.391*** |
| Classrooms in good condition (%) | 922 | 49.61 | 36.21 | 531 | 52.14 | 37.99 | 2.529 |
| Teacher rooms | 937 | 0.57 | 0.49 | 536 | 0.74 | 0.44 | 0.170*** |
| Library | 937 | 0.88 | 0.33 | 536 | 0.88 | 0.33 | -0.000 |
| Laboratory | 937 | 0.66 | 0.47 | 536 | 0.71 | 0.45 | 0.050 |
| Auditorium | 937 | 0.10 | 0.30 | 536 | 0.12 | 0.33 | 0.024 |
| Administrative building | 937 | 0.86 | 0.34 | 536 | 0.91 | 0.28 | 0.050* |
| Sports fields | 937 | 0.00 | 0.00 | 536 | 0.00 | 0.00 | 0.000 |
| Perimeter fence | 937 | 0.00 | 0.00 | 536 | 0.00 | 0.00 | 0.000 |

The table shows the averages for the control and treatment groups for the sample of emblematic schools during baseline (2006-2009). All panels except Panel E were calculated using information from the School Census. Panel E used information from the Student Census Evaluation. The last column shows the difference in mean between treatment and control group. Asterisks indicate whether the difference is significant for the following levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A.2:** Balance table for the competing private schools (buffer 2 km)

| | Control (1) | | | Treatment (2) | | | T-test (2)-(1) |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | Diff |
| Panel A. ***School outcomes*** | | | | | | | |
| School exit | 14347 | 0.20 | 0.40 | 14425 | 0.21 | 0.40 | 0.002 |
| Total enrollment | 14347 | 82.63 | 119.22 | 14425 | 101.31 | 148.78 | 18.675** |
| Panel B. ***Student academic results*** | | | | | | | |
| Approved (%) | 10935 | 95.62 | 8.12 | 11038 | 95.27 | 8.03 | -0.347 |
| Dropout (%) | 10935 | 2.34 | 4.81 | 11038 | 2.41 | 5.34 | 0.072 |
| Panel C. ***Standardized tests*** | | | | | | | |
| Math z-score | 4181 | 0.21 | 0.86 | 4079 | 0.38 | 0.86 | 0.174*** |
| Reading z-score | 4174 | 0.44 | 0.78 | 4075 | 0.70 | 0.76 | 0.257*** |
| Panel D. ***Teaching Staff*** | | | | | | | |
| Number of teachers | 9635 | 7.37 | 7.63 | 10051 | 8.72 | 10.47 | 1.350*** |
| Number of students per teacher | 9635 | 34.72 | 70.44 | 10051 | 37.54 | 68.00 | 2.823 |
| Female (%) | 9635 | 52.24 | 34.07 | 10051 | 53.64 | 33.66 | 1.397 |
| Teachers with higher education (%) | 7520 | 99.74 | 2.94 | 7819 | 99.62 | 3.93 | -0.119** |
| Teachers with tenure (%) | 8258 | 30.22 | 41.11 | 8687 | 36.34 | 42.56 | 6.120*** |
| Teachers with management positions (%) | 9635 | 23.26 | 34.37 | 10051 | 22.32 | 33.88 | -0.945 |
| Panel E. ***Infrastructure variables*** | | | | | | | |
| Access to basic services | 11422 | 0.90 | 0.30 | 11462 | 0.88 | 0.33 | -0.021 |
| Number of classrooms | 11422 | 10.80 | 7.01 | 11462 | 12.14 | 9.21 | 1.341** |
| Clasrooms in good condition (%) | 10936 | 94.47 | 17.95 | 10752 | 96.56 | 13.82 | 2.091** |
| Teacher rooms | 11422 | 0.53 | 0.50 | 11462 | 0.61 | 0.49 | 0.081** |
| Library | 11422 | 0.53 | 0.50 | 11462 | 0.56 | 0.50 | 0.035 |
| Laboratory | 11422 | 0.22 | 0.41 | 11462 | 0.28 | 0.45 | 0.063** |
| Auditorium | 11422 | 0.05 | 0.21 | 11462 | 0.05 | 0.22 | 0.004 |
| Administrative building | 11422 | 0.85 | 0.36 | 11462 | 0.83 | 0.37 | -0.013 |
| Sports fields | 11422 | 0.00 | 0.00 | 11462 | 0.00 | 0.00 | 0.000 |
| Perimeter fence | 11422 | 0.00 | 0.00 | 11462 | 0.00 | 0.00 | 0.000 |

The table shows the averages for the control and treatment groups for the sample of competing private schools (in the buffer of 2km) during baseline (2006-2009). All panels except Panel E were calculated using information from the School Census. Panel E used information from the Student Census Evaluation. The last column shows the difference in mean between treatment and control group. Asterisks indicate whether the difference is significant for the following levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table A.3:** Balance table for the competing public schools (buffer 2 km)

| | Control (1) | | | Treatment (2) | | | T-test (2)-(1) |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | Diff |
| Panel A. ***School outcomes*** | | | | | | | |
| School exit | 6265 | 0.03 | 0.16 | 4499 | 0.02 | 0.13 | -0.008 |
| Total enrollment | 6265 | 482.71 | 382.29 | 4499 | 491.10 | 374.52 | 8.389 |
| Panel B. ***Student academic results*** | | | | | | | |
| Approved (%) | 6014 | 87.36 | 8.85 | 4363 | 87.67 | 9.19 | 0.314 |
| Dropout (%) | 6014 | 5.43 | 5.16 | 4363 | 5.26 | 5.09 | -0.166 |
| Panel C. ***Standardized tests*** | | | | | | | |
| Math z-score | 2728 | 0.01 | 0.92 | 2075 | 0.02 | 0.85 | 0.012 |
| Reading z-score | 2734 | -0.09 | 0.81 | 2074 | 0.06 | 0.77 | 0.146 |
| Panel D. ***Teaching Staff*** | | | | | | | |
| Number of teachers | 5815 | 10.17 | 12.60 | 4296 | 12.37 | 15.35 | 2.204** |
| Number of students per teacher | 5815 | 156.49 | 227.42 | 4296 | 135.32 | 209.57 | -21.175 |
| Female (%) | 5815 | 51.03 | 33.21 | 4296 | 52.61 | 31.91 | 1.588 |
| Teachers with higher education (%) | 3956 | 99.45 | 5.70 | 3035 | 99.38 | 5.40 | -0.069 |
| Teachers with tenure (%) | 4908 | 66.91 | 40.82 | 3780 | 70.72 | 38.16 | 3.817* |
| Teachers with management positions (%) | 5815 | 27.87 | 35.26 | 4296 | 23.18 | 32.74 | -4.688* |
| Panel E. ***Infrastructure variables*** | | | | | | | |
| Access to basic services | 6098 | 0.84 | 0.37 | 4416 | 0.89 | 0.32 | 0.051* |
| Number of classrooms | 6098 | 16.73 | 9.96 | 4416 | 17.69 | 11.14 | 0.963 |
| Classrooms in good condition (%) | 6035 | 54.68 | 37.72 | 4345 | 59.15 | 38.03 | 4.471* |
| Teacher rooms | 6098 | 0.38 | 0.49 | 4416 | 0.41 | 0.49 | 0.034 |
| Library | 6098 | 0.62 | 0.48 | 4416 | 0.64 | 0.48 | 0.021 |
| Laboratory | 6098 | 0.32 | 0.47 | 4416 | 0.36 | 0.48 | 0.037 |
| Auditorium | 6098 | 0.05 | 0.22 | 4416 | 0.04 | 0.20 | -0.007 |
| Administrative building | 6098 | 0.77 | 0.42 | 4416 | 0.77 | 0.42 | 0.007 |
| Sports fields | 6098 | 0.00 | 0.00 | 4416 | 0.00 | 0.00 | 0.000 |
| Perimeter fence | 6098 | 0.00 | 0.00 | 4416 | 0.00 | 0.00 | 0.000 |

The table shows the averages for the control and treatment groups for the sample of competing public schools (in the buffer of 2km) during baseline (2006-2009). All panels except Panel E were calculated using information from the School Census. Panel E used information from the Student Census Evaluation. The last column shows the difference in mean between treatment and control group. Asterisks indicate whether the difference is significant for the following levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Figure A.1:** Direct Dynamic effects on enrollment

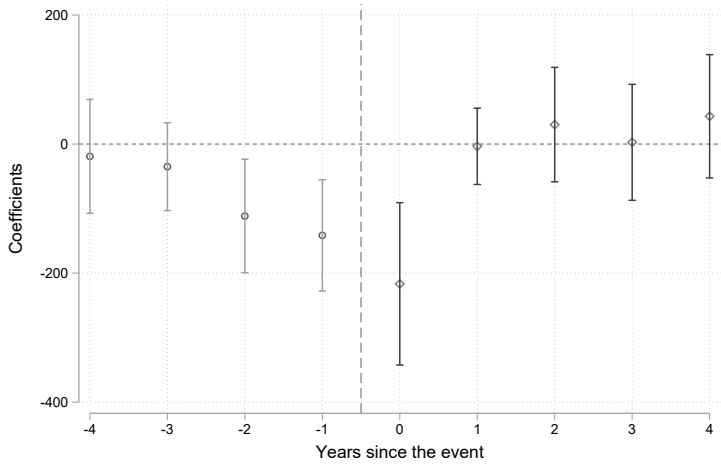
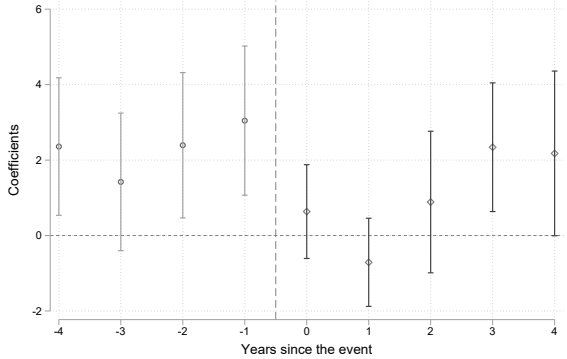



**Figure A.2:** Direct Dynamic Effects on Student's Achievement

**((a))** Approved (%)




**((b))** Dropout (%)

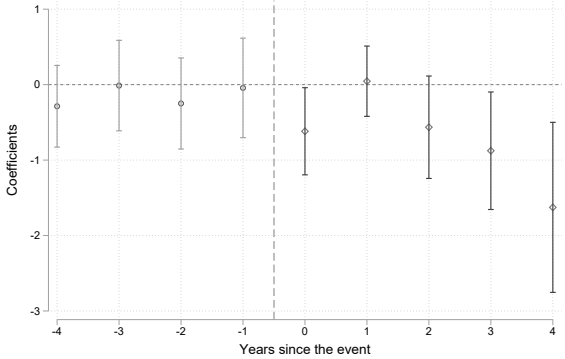
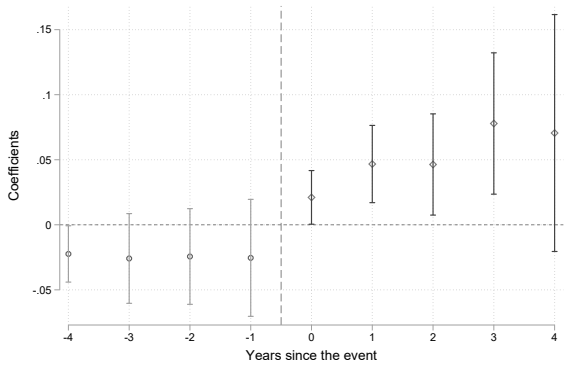
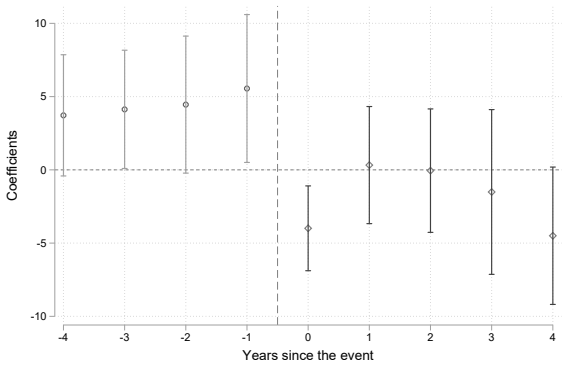


**Figure A.3:** Spillover Dynamic Effects School Exit and Enrollment

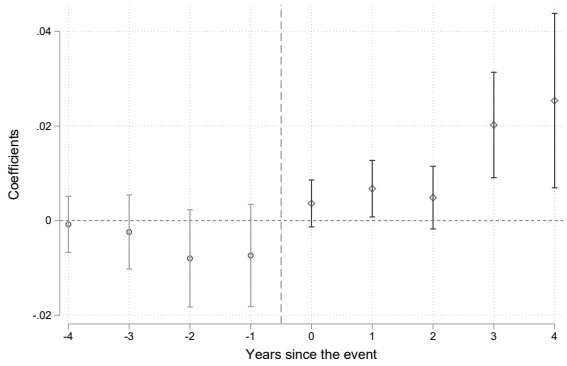
**((a))** Private school exit




**((b))** Private enrollment




**((c))** Public school exit




**((d))** Public enrollment

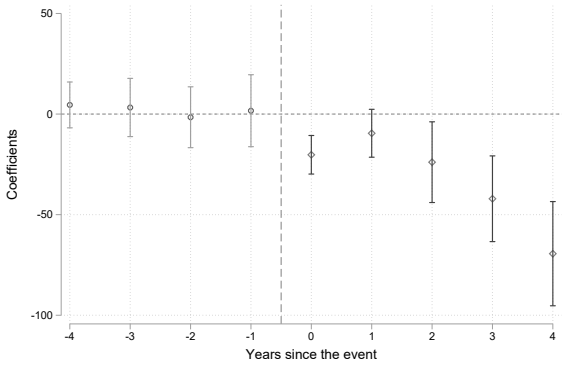


**Figure A.4:** Spillover Dynamic Effects on Private School's Student Outcomes

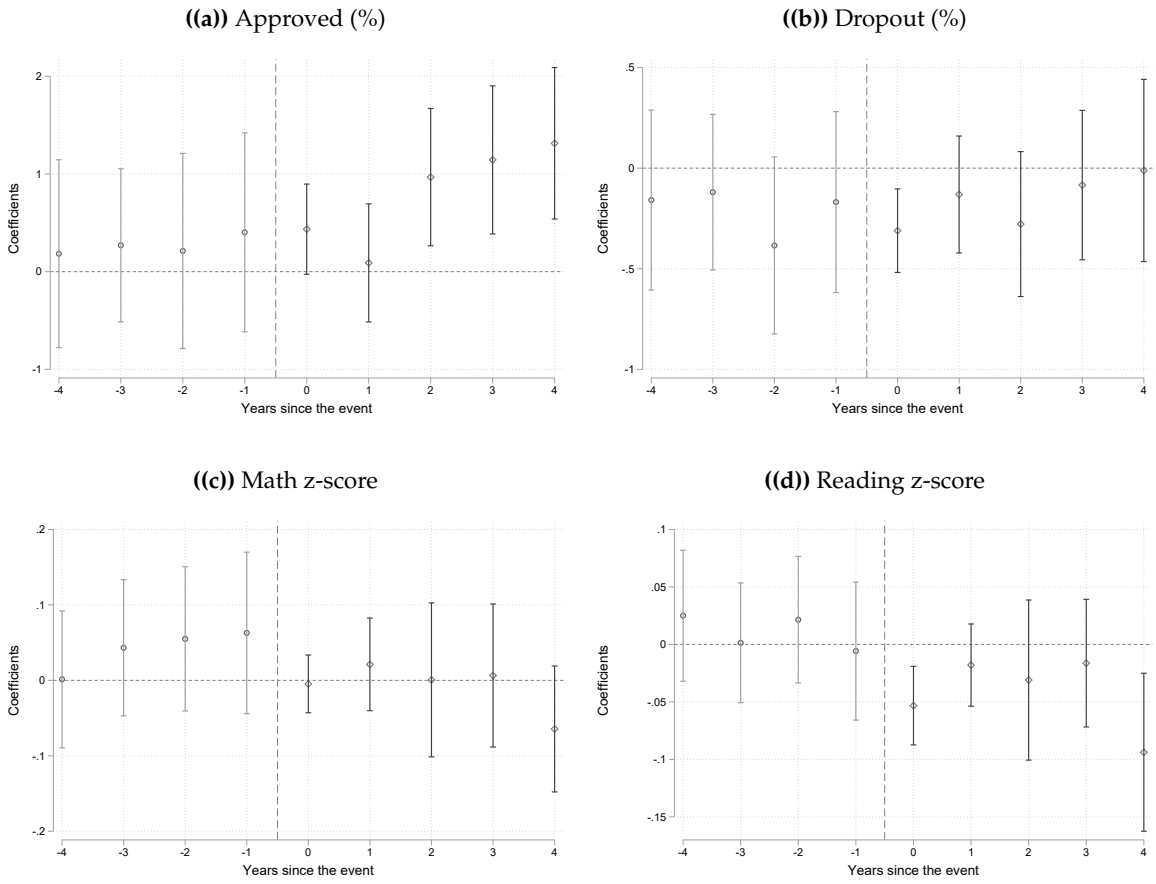
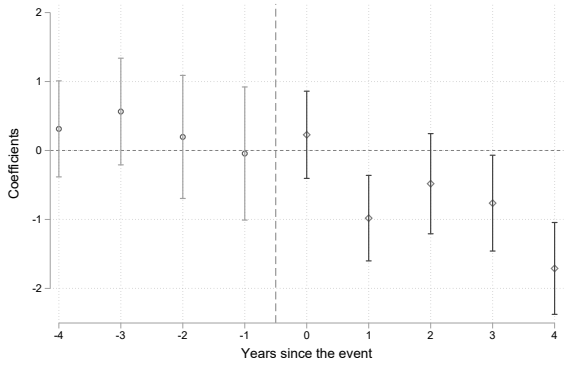
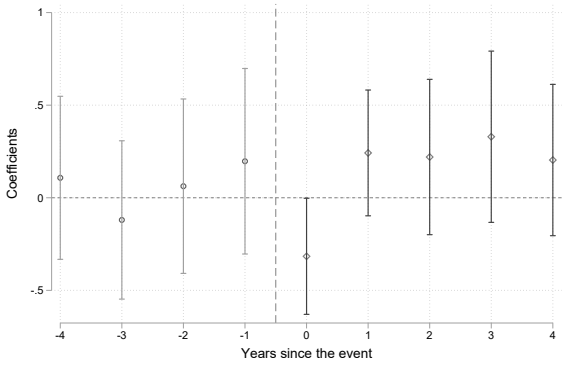


**Figure A.5:** Indirect Dynamic Effects on Public School's Student Outcomes

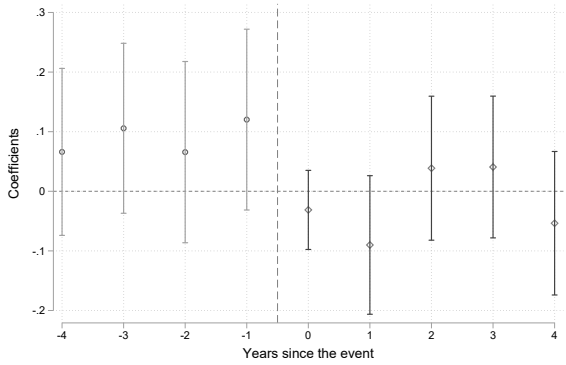
**((a))** Approved (%)




**((b))** Dropout (%)




**((c))** Math z-score




**((d))** Reading z-score