Road to the Future: Identifying Impacts of Roads on Education in Colombia *

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ABSTRACT

This study evaluates the impact of the road concessions program on education in Colombia. The results reveal a decrease in the fraction of students participating in the labor force in schools located near roads, accompanied by an increase in average reading and math scores and the fraction of students completing higher education. The evidence suggests positive effects on the accumulation of human capital, with a stronger impact on public schools compared to private schools. This research provides valuable insights into the potential effects of infrastructure development on the educational outcomes of students in Colombia.

JEL Codes: O28, I21.

Keywords— Road concession, education, human capital accumulation, Dynamic DiD

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1 Introduction

In Colombia, a significant portion of schools are isolated from the rest of the world by a lack of access to paved roads. 50% of schools in the country are situated more than 1 kilometer from a road that provides 24/7 vehicular access, with a staggering 24% located over 5 kilometers away from such a road.

In this study, I make a contribution to the literature on the impact of road infrastructure development under concession agreements in Colombia. I find evidence of a decrease in the labor force participation of youth students and an increase in average scores in standardized tests. Additionally, I provide evidence of heterogeneous effects between public and private schools, with a higher impact on public schools. Finally, I find an increase in the fraction of students who completed some level of higher education.

Previous studies have focused their efforts at estimate the effect of road infrastructure development on macroeconomic variables (Emran and Shilpi, 2012 ; H. Hanson, 2005 ; Head and Mayer, 2011; Sanchis-Guarner, 2012; Gibbons and Machin, 2005; Faber, 2014; Datta, 2012; Burgess and Donaldson, 2014 ; Atack and Margo, 2011; Asher and Novosad, 2020)

The literature about the impact of roads on education suggest that Roads have mixed impacts on education performance and quality. Mukherjee, 2012 found a positive impact on school enrollment. Adukia et al., 2020 found that children in India stayed in school longer and performed better on standardized exams as a result of new roads, suggesting a positive impact on education performance. However, Khumalo and Mji, 2014 found that educators in rural South African schools identified a number of issues that they felt play a role in the learning and teaching context, including poor infrastructure provisioning, suggesting a negative impact of poor infrastructure on education quality.

In Colombia, the roads have had as their main purpose the improvement of the connection between commercial and economically important cities. Road concessions in Colombia emerged in 1994 with the concession of the road Bogota-Villavicencio, with the purpose of supplying the lack of state resources for investment in the national road network.

The Colombian educational system consists of initial education, preschool education, basic education (5 primary and 4 secondary grades), secondary education (2 grades leading to a bachelor's degree), and higher education. I examine the schools located near roads under a concession agreement to assess the effect on the academic performance of students. Additionally, I evaluate the participation of students in the labor force and its impact on their enrollment in higher education to understand the accumulation of human capital.

The difference-in-differences specification with dynamic treatment time (Dynamic DiD) is used in this study to estimate the causal effect of roads on education (Howard White, 2014). In this estimation, the treatment groups are those schools near intervened roads while the control groups are those schools near the last intervened road (Sun and Abraham, 2021).

Organization of the paper: The remainder of this article is organized as follows. Section 2 provides a literature review on how a road impact on education. Section 3 presents the institutional context that relates to political regulations, roads and concession agreements, and education in Colombia. I discuss the conceptual framework including the mechanism by which a road can affect education in Section 4. The data I have used in this study are described in Section 5. Section 6 presents the empirical strategy that allows estimating the causal inference. I discuss the results in section 7 and finally in section 8 I conclude. The tests, as well as additional results, are reported in the Appendix.

2 Literature Review

The benefits of the extension of road networks have been discussed and documented in different literature focused on growth, inclusion, and sustainability in a developing country context. Some empirical exercises, has point to the fact that the roads infrastructure improvements and developments have had effects over economic variables in different observation levels.

Berg Claudia N, 2015 disclose different empirical approaches made to estimate the effect of roads on different outputs (transportation cost, access to transport service, etc.). In the report (Berg Claudia N, 2015) they show different strategies, such as the use of the presence or absence of a road in a geographic unit to estimate the effect of a road on development factors (Faber, 2014; Datta, 2012; Burgess and Donaldson, 2014 ; Atack and Margo, 2011).

Several studies have explored the relationship between road infrastructure and education outcomes. Idei et al., 2020 found that improved roads motivated households to purchase vehicles, which in turn led to improved school attendance and reduced school travel distance. Zipporah M Mokaya, n.d. found that adequate and well-spaced classrooms were associated with improved academic achievement, attendance, and retention.

Mukherjee, 2012 found that improved access to school due to better roads increased school enrollment by 22% in 2009, and N. Dragutinovic and D. Twisk, n.d. discussed the characteristics of good education programs. Hong and Zimmer, 2016 found that capital expenditures had a positive effect on student proficiency levels, while S. Raftery and L. Wundersitz, n.d. highlighted the lack of information on the efficacy of current road safety educational programs. L. Musyoka, n.d. found that schools should be sensitized to acquire physical facilities that are important for academic success, and J. Isernhagen and N. Bulkin, n.d. found that highly mobile students scored lower on criterion-referenced assessments than their non-highly mobile peers.

Other commonly used strategies are based on using the time to the closest carts as a source of variation (Faber, 2014; Emran and Hou, 2013 ;Ghani et al., 2015). Studies that normally focus on evaluating the economic effect on the production and productivity of a region, inclusiveness, and even sustainability, have led to the use of more sophisticated variations as indices of market access, or instrumental variables on the lowest path cost where a road should be crossed (Emran and Shilpi, 2012 , H. Hanson, 2005 , Head and Mayer, 2011, Sanchis-Guarner, 2012, Gibbons and Machin, 2005).

The World Banck (Evans and Popova, 2016) analyzed stuides about useful interventions for better student performance, interventions that provide information about school quality, or even basic infrastructure (such as desks) to achieve the greatest improvements in student learning. This implies that if parents know about improvements in the infrastructure of schools or near them, they will have a perception that they are more suitable conditions to study, and therefore they will have greater preference for their children to study in those schools.

Donaldson, 2018, evidence the importance in long-term of railroad infrastructure, he found in a general equilibrium trade model of railroads infrastructure that, decreased trade costs and interregional price gaps, increased interregional and international trade and increased real income levels. Conclusions of Donaldson in long-term are studied by Quintero and Sinisterra, WP2022 for short-term who measures road improvement and construction as a function of production and inequality in Colombia from 1993 to 2012. I focused this exercise on the effects of road infrastructure improvements under a concession treatment on educational outcomes at the scale of schools.

Fernald, 1999, in his research aims to answer the question of how changes in roads affect the relative performance of the productivity of industries in the US from 1953 to 1989, Finding that the affects over the productivity are mainly reflected in the intensive automotive production. Along with that, Fernández et al., 2020 shows how transportation infrastructure promoted long-term employment opportunities and broke the labor bond between parents and children. These previous investigations open a door understand the role of labor force participation of students from treated schools. Which is analyzed in the results of this article.

This paper contributes to a literature evidence of effect of roads on educations outcomes. Differing from Adukia et al., 2020 who examines the educational effects of 115,000 new roads built, finding that children stay in school longer and perform better on standardized tests. I evaluated the heterogeneity between public and private schools and show the effects over labor participation and accumulation of human capital in the same analysis.

In shot-term, I do not find evidence that schools located at more than two kilometers from the road under a concession agreeme in Colombia are impacted by the construcction. In the same sense, Yasar Avsar, 2004 found an effect of noise on indicators of education in schools located less than 1.45 km from the road.

3 Context and Background

The political constitution of Colombia provides us with an institutional context. The article 67 establishes that: “Education is a right of the person and a public service that has a social function; with it, access to knowledge, science, technique, and the other goods and values of culture..." (own translation of the political constitution of Colombia, Article 67)

The constitutional court of Colombia under judgment T-743/13, admits that: *"... the right to education has four structural and interrelated components..."* Such components are as follows: **Availability, Accessibility, Adaptability, and Acceptability**. The availability component alludes to the satisfaction of the educational demand; the accessibility dimension protects the individual right to enter the education system in conditions of equality, in the adaptability component, the system must adapt to the needs of its students, valuing the social and cultural context in which they operate, in favor of avoiding school desertion, the acceptability searches for the guarantee of educational quality. Altogether, these four components can be improved thanks to the investment in road infrastructure. Road modifications or constructions attempt to address all of these components (Availability, Accessibility, Adaptability, and Acceptability).

The road concession system it's a strategy that works with private investment resources. The national roads institute (guarantor of road development and maintenance in the country) establishes a contract with the applicant firm, giving them for a limited amount of time the construction, rehabilitation, or maintenance of a road, giving them in return the money recollected in that period by the vehicle tolls. At the end of the agreed period, the concession road returns to the state. At the moment which I write this article, the concessions have been carried out in stages called: First, second, third, fourth, and fifth-generation Muñoz Prieto, 2002. In this article, I take as treatment the construction or improvement of roads of the 3G concession, that had as purpose, in the words of the council of state, the development of road corridors that would connect the main centers of consumption with the main centers of production and these with the ports.

The stages of construction of a concession road, are separated into: 1. Planning, 2. Designs, 3. Design and programming, 4. Construction, 5. Operation and reversal. The planning stage is carried out by the "Instituto Nacional de Vias(INVIAS)", the national infrastructure institute, and the ministry of transportation and corresponds to the study and design of the road, which includes budget and validity of the item, route, affectation among others. The second stage (Design and programming) covers the execution of the contract until the moment in which the construction begins. The third stage (Construction) covers the start of works until the date on which the entity receives the works and the necessary equipment for the road to enter service. The fourth and last stage(Operation) covers from the moment in which INVIAS receives the works until the date when the road returns to the nation. According to Nestor Sanchez[1]:

[1]CEO of BTS Concesiones, Concession in charge of the Briceño - Tunja - Sogamoso section, with a contract of 206 km, of which 21.13 km of Double lane contracted, 147.56 km the Second lane contracted, and 181, 60 km Rehabilitation contracted and former manager of the Alto Magdalena concession

"...The Design and programming stage contemplates periods of about one year for 3G and 4G routes and about 1 and six months for 5G routes. It also points out that although in all cases the construction stage differs times can be between 3 to 5 years and for operation stages, the estimated time is 29 years..." Sanchez, 2022

In other words, the 6.5 years before the start of operation of the road, turn out to be the years in which the first deliveries are made, the first contracted sections come into operation. This implies that even though the road is delivered, early deliveries result in 6 years before phase four regarding the operation of the road. This anticipation makes it of great value to evaluate the effect of the track in different periods, such as at the time of the delivery date of the track, the date on which the track has reached 10% progress, and the date in which the act of beginning construction of the road was signed.

3.1 Mechanisms

Road interventions have implications on the income of families living near the intervened roads. In the results chapter, a special section is presented that demonstrates the impact of roads on families living near the road.

Several studies, including Kathryn Wilson, 2002, Paul Gregg, L. Macmillan, 2009 ,Tao Lin, Han Lv, 2017 and A. Chevalier, Gauthier Lanot, 2002 have shown that family income plays a significant role in children's education. Higher family income has been found to increase the likelihood of investing in education, resulting in better education quality and higher educational attainment. However, the mechanism through which family income affects education quality is not entirely clear.

One possible explanation for the impact of family income on education is the accessibility and quality of transportation infrastructure, such as roads. Josh Kinsler, Ronni Pavan, 2011 found that family income significantly affects the quality of higher education, especially for high-ability individuals. Jong-Wha Lee, R. Barro, 1997 found that family characteristics such as income and education of parents have strong effects on student performance. J. Blanden, Paul Gregg, 2004 found that income has a causal relationship with educational attainment. Furthermore, Paul Gregg, L. Macmillan, 2009 found that the relationship between family income and education is one of the key drivers of intergenerational income mobility across time in the UK.

The availability of good quality roads makes it easier for students to get to school, which in turn increases the likelihood of investing in education. In addition, better road infrastructure also increases access to resources such as libraries, commercial points, tutoring centers, and extracurricular activities, which can further enhance the educational experience.

(Honda - Puerto Salgar - Girardot)

Furthermore, improved road infrastructure can also attract new businesses and industries to an area, leading to increased economic opportunities and higher family incomes, which can further support investments in education.

I this study, I present evidence on the impact of the road intervention on the participation of young students in the labor force. Based on the hypothesis that students who reduce their participation in the labor force devote more time to study, an improvement in language and mathematics scores is found. In the long run, this improvement has a significant effect on human capital accumulation.

$$\text{Road Intervention} \Rightarrow \uparrow w_F \Rightarrow \downarrow L \Rightarrow \uparrow s \Rightarrow \dot{H}$$ [2]

Overall, while the relationship between family income and education quality is clear, the mechanism through which this relationship occurs is complex and multifaceted. Nevertheless, the evidence suggests that improving road infrastructure, as suggested by Josh Kinsler, Ronni Pavan, 2011, can play an important role in increasing access to education, improving education quality, and ultimately increasing economic opportunities and social mobility.

4 Data

The information that this study requires is the address of the schools that participate in the SABER 11 exam from 2006 to 2019, the results of the standardized test of SABER 11 schools from 2006 to 2019, the road construction plan in achievement at the time of signing the initiation act, The results of students who studied near a road in concession and who completed a university study.

4.1 Schools

I developed a custom script which uses the google maps API to locate the geographical position of approximately 21000 school addresses. For this paper i used approximately 11780 schools correspond to secondary schools (see Figure 4.1).

4.2 Roads

In this study, 987 schools were implicated within a radius of 1000 meters from the road which represent the focus of this research. Of the 987 schools 250 were private schools and 737 where public schools. On average, over the 393 municipalities considered, everyone has 5.5 schools. The Proportion of students who participated in labor force in private schools was 12.9% while

[2]Where w_F is the Income family, L is the labor force participation, s is the studying time and $\dot{H} referstohumancapitalaccumulation$

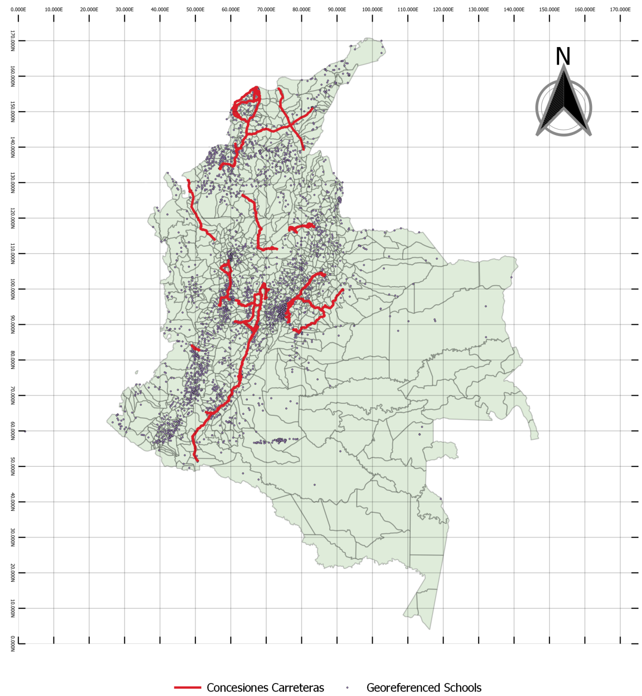


Figure 4.1: Roads under concession and schools georeferenced. Purple points ilustrate the Georeferenced schools and the red lines ilustrate the roads under concession at considerated tim.

10.4% was the percentage presented in public schools. The Proportion of bachelor students who finished some university study from private institution was 2.3% while 1.4% was the percentage of students finished some university study in public schools.

I use the georeferenced map of roads under concession for construction or improvement in Colombia to create radial buffers [3] de 1 Km a 4.5 Km. The radial buffers allow me to cluster the schools according to the distance in which they are located. Such that schools far from the roads are best to verify the robustness of the results. Schools that are more than two kilometers away from the road do not affect the construction of a new road.

The time periods required for a road construction is in average 13 years. In average the time require for reaching the 10% advance is 7.25 years and 2 years more for reaching the 50% of advance of the road. The concession length had an average of 191 km. The shortest concession length was 31km. The largest concession length was 491 km. In average there are 3 tolls by every road built.

[3] A buffer is a zone that is drawn around any point, line, or polygon that encompasses all of the area within a specified distance of the feature

4.3 Academic performance

The State exam for Secondary Education, Saber 11, is made up of five tests: Reading Literacy, Mathematics, Social and Citizenship, Natural Sciences and English. The Saber 11 exam can be taken by students who are finishing the eleventh grade and who have obtained a bachelor's degree or have passed the baccalaureate validation exam. Ordinarily the exam consists of 5 tests: Mathematics: 50 questions. Critical reading: 41 questions. Social and citizen: 50 questions. Natural sciences: 58 questions. English: 55 questions. Due to the contingency generated by the COVID19 pandemic, the number of questions for the virtual exam that was presented in 2020 and 2021 was different from the ordinary volume of questions.

To avoid measurement problems given by outliers in the results of the Saber 11 exam. I take the 50th percentile by a school, which is normalized with the national result, obtaining the normalized result of the mean for the math and reading literacy tests. since 2006 untill 2019. Descriptive statistics of the data collected for this study are shown in the appendix A.1.

The Average of all schools located within a radius of 1000 meters from the road in math standardized score was 0.428, The Average in reading literacy standardized score was 0.486 The average math score in private schools were 0.466 while in public institutions were 0.417 The average reading literacu score between private schools were 0.521 while in public schools were 0.476 (See table 1).

A relationship between roads and results of the Saber 11 exam is presented in the figure 4.2, which, on the left, presents the standardized result of the mathematics test, and on the right the standardized results of the Saber 11 exams of reading comprehension. This spatial correlation details that in the departments where there are more roads, better results are observed in both standardized tests.

Table 1: Descriptive statistics of schools within a radius of 1000 meters from the road

Schools within a radius of 1000 meters from the road						
	Treated schools			Control Schools		
	mean	median	sd	mean	median	sd
Students with university studies *	0.148	0.071	0.192	0.127	0.058	0.165
Students in labor force +	0.101	0.012	0.162	0.142	0.042	0.197
Reading literacy Score	0.491	0.480	0.057	0.484	0.478	0.051
Mathematics score	0.433	0.410	0.082	0.425	0.405	0.074
Number of schools		510			485	
Number of observations		6565			5981	

*Fraction of students who finished a university study. +Fraction of students who participate in labor force. Over a population of schools within a radius of 1000 meters from the road, this table shows that there is balance (acording to the mean and standard desviation) between treated and control schools, before the treatment, in mathematics scores, reading literacy scores, the fraction of students who participates in labor force and the fraction of students with university studies. In addition it also shows similarities between the median of these variables over the two groups evaluated. The last two rows expouse balance between the sample size in those two groups.

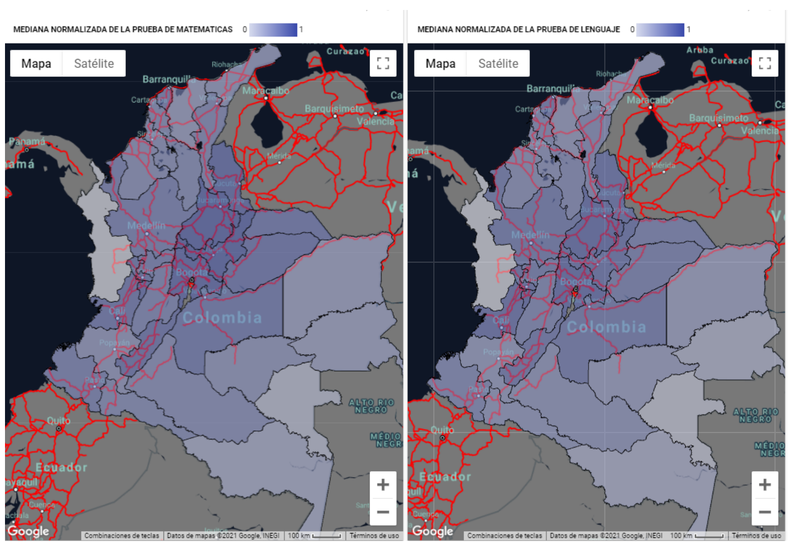


Figure 4.2: The spatial relationship between tests Saber11 road coverage at a departmental scale. The red line indicates the road network, and the polygons in the gray-to-blue scale show the scale of results in the saber 11 test.

5 Empirical Strategy

The difference-in-differences specification with dynamic treatment time (Dynamic DiD) is used in this article to estimate the causal effect of roads on education. In this approach, the variation is determined by the construction of the road and by the distance between schools and the roads under concession. In the short term, this variation must be exogenous.

In this article I estimated the effect of roads on education using the estimators proposed by Sun and Abraham, 2021. To obtain a robust estimate, I compare the results with the estimators of TWFE and the estimators proposed by Callaway and Sant'Anna, 2021.

Furthermore, Sun and Abraham, 2021 and Callaway and Sant'Anna, 2021 do not assume parallel trends in relation to the outcome of those who are not treated, instead, they propose assumptions of parallel trends in the outcome of those who are not treated over time. As a Dynamic DiD, the present model must satisfy the next three assumptions (Sun and Abraham, 2021 assumptions).

Assumption 1. Parallel Trends in Baseline Outcomes: Never-treated schools are likely to be different, even before the treatment period, from the treated schools, and because of this, the evolution of baseline outcomes could not share the same evolution of treatment outcomes. To comply with this assumption, the design of this evaluation is based on comparing schools where a road was built, compared to schools in which the road was planned but by 2019 the construction had not started. In this study, the treatment is allocated as an exogenous decision of the schools, and schools are not considered by policy makers.

Assumption 2. No Anticipatory Behavior Prior to Treatment: it refers there is not any treatment effect in the pre-treatment period. Roads are planned to link economically relevant cities or municipalities between them. The position and performance of the schools relative to the road are clearly exogenous to the road plan (i.e The trace of the road is not based on the qualities of the school).

Assumption 3 Treatment Effect Homogeneity: it refers to Treatment effects need to be the same across cohorts in every relative period for homogeneity to hold, whereas, for heterogeneity to occur, treatment effects only need to differ across cohorts in one relative period (Sun and Abraham, 2021). That is why to avoid the non-fulfillment of the assumption due to concession contract characteristics or local decisions that change contract characteristics due to political effect or contract terms, I exclude roads under concession in the 1G, 2G, and 5G programs, as well as roads built by INVIAS. Therefore, I compare educational outcomes in schools before and after road construction, loosely controlling for time-varying regional shocks and static differences between schools receiving roads in different years.

The roads under a concession agreement are national projects, the general purpose of the road under a concession agreement is to join two economically important points, the intermediate points are exogenous to the decisions of the road intervention. In a road concession contract, the pre-construction stage defines, according to the mining-geological characteristics of the areas to be intervened, the moment in which the intervention of a section of the road begins. The schools located close to a road do not define the moment in which the school is intervened. Since

I include **fixed effects by schools** for unobserved school-specific factors that may have influenced the timing of road construction, **time fixed effects** for policies, and state-specific shocks that vary by time in the dynamic DiD model of TWFE estimators and the Sun and Abraham, 2021 estimations. **Cluster at school level** is included in the three estimates to be made to control the variance of internal errors for each school.(See Subsection 5.1).

In this article, one of the greatest difficulties in estimating the causal effect of the roads on education is based on the fact that the effect on education are present throughout all the concession stages of construction. The Dynamic DiD model contemplates a discrete treatment time, which for this article is a challenge since the roads represent a treatment that occurs from the beginning of the construction until the final stage of the construction.

The equation 1 shows the general estimation of TWFE, where Y refers to the outcome of the individual i in the period t, T refers to the treatment period, S refers to the period t before treatment and M refers to the period t after treatment. That is why it is necessary to evaluate the effect at different stages of road construction progress.

$$Y_{i,t} = \sum_{\varphi=-S}^{T_{-1}} \mu_{\varphi} \cdot D_{i,\varphi} + \sum_{\varphi=T_{+1}}^{M} \mu_{\varphi} \cdot D_{i,\varphi} + \sigma_t + \sigma_i \varepsilon_{i,t} \tag{1}$$

The anticipation assumption of Sun et. al. and Callaway et. al. refers that the performance of schools does not depend on their future treatments (i.e. schools do not get be treated based in their academic achievements). The table 2 shows the distribution of years that a concession takes from the moment the agreement is signed until, according to its different stages, it reaches one hundred percent advanced.

5.1 Effect of the road concessions program on education outcomes.

In contrast with other kinds of interventions, the roads do not appear instantly. They are involved in a building process, on average Colombian roads buildings long for 7.5 years, though these processes have stages that are measured here as their percentage of completeness (see figure 5). In this context would be problematic with parallel trends assumption if we compare the outcomes before and after the construction. What we observe in this case is that we have a time of treatment since the construction began until the road is finished, that is why Callaway and Sant'Anna, 2021 estimation don't work in this case. Nevertheless, Sun and Abraham, 2021 estimation could work, because its flexibility with parallel trends but it ought to be evaluated.

Table 2: Statistics of the progress times of the roads under a concession agreement

	Advance 1 (10%)	Advance 2 (50%)	Advance 3 (100%)
max	23	23	25
min	2	2	6
mean	5,5	7	12
median	4	5	13

Note: Advance 1. Years from the signature of the concession until reaching a ten percent of the plan. Advance 2. Years from the signature of the concession until reaching a fifty percent of the plan. Advance 3. Years from the signature of the concession until reaching a hundred percent of the plan. This table present in rows the maximum, the minimum, the mean and the median of the years involved in advances described above.

what I propose for solving this estimation problem is to measure the impacts of the roads in education at three specific percentages of completeness (10%, 50% and 100%) . Given that, my concept of treated school is defined as a function of these percentage, that is, I compared the nearest schools when the road is 10% completed and non-treated schools (0% completed), and so on with the other percentages mentioned above. I found various levels of treatment, even when the road its not finished.

To estimate the causal effect of road construction on education, in this article I assess the effect given each construction advance time (see table 2). In this way, I assess the effect that each stage of road construction has on education. I define three treatment reference periods, which cover from the beginning of the concession until the delivery of the construction of the road. As Nestor Sanchez Sanchez, 2022 commented, there are anticipated deliveries and stipulated dates in the concession contract. The three treatment times are:

- The year in which the Work Initiation Act was signed,
- The year in which the roads have reached 10% of execution,
- The year in which the road have reached 100% of the plan. [4]

In order to estimate the dispersion of the effect of road construction on education I studied the effect on schools located at different distances from the road (between 1,000

[4]EXECUTIVE REPORT HIGHWAY C-14 of contract 377 of 2002 https://www.contratos.gov.co/consultas/detalleProceso.do?numConstancia=16-1-156465, (CARRETERO EXECUTIVE REPORT C-14) where it is observed that more than 50% of the plan of the work was delivered 5 years before the final delivery

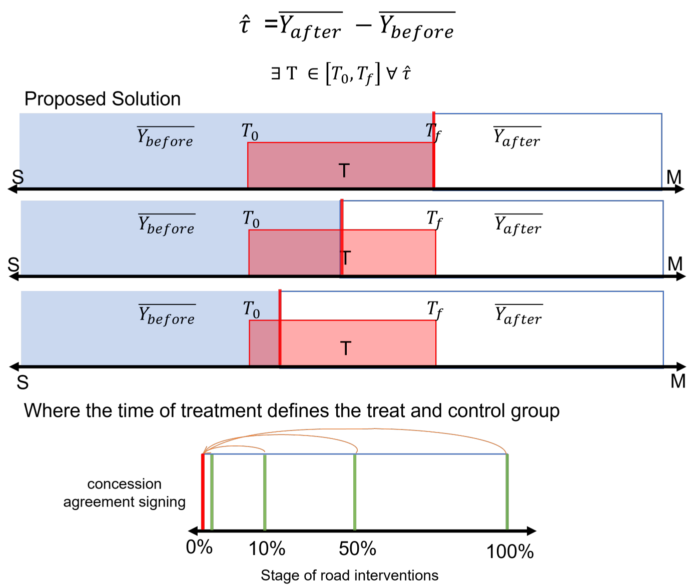


Figure 5: The temporary relationship between after and before the treatment, it represents that the treatment time is not inmediate, but imply differents satges of completeness.

and 4,000 meters away, See Figure 5.1). Schools located far from the roads do not have the same guarantees as schools near the roads in terms of adaptability, accessibility, availability, and acceptability as ordered by the constitutional court. The study of the dispersion of the effect verifies the causal effect. When schools close to a road under concession (less than a kilometer) are affected, but this effect disappears as the distance to the road is greater then this effect should be exclusive of the construction of the road else the effect is not exclusive of the construction of the road.

Wheater there is a causal effect of the construction of the roads in any of its stages on education, this effect will dissipate as the distance from the school to the road under construction increases. In this article, I demonstrate the causal effect with the estimator of Sun et. to the. on the following subgroups(See Figure 5.1):

- Subgroup 1. Schools located between 1000 meters and 1500 meters from the road,
- Subgroup 2. Schools located between 1500 meters and 2000 meters from the road,
- Subgroup 3. Schools located between 2000 meters and 2500 meters from the road,
- Subgroup 4. Schools located between 2500 meters and 3000 meters from the road,
- Subgroup 5. Schools located between 3000 meters and 3500 meters from the road,

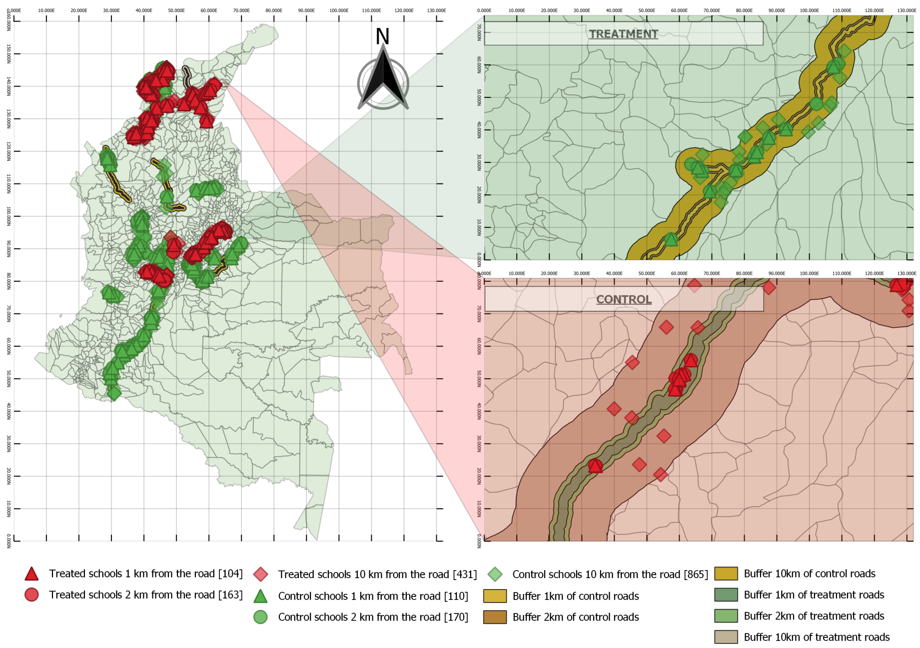


Figure 5.1: Location of schools treated (green vignettes) and control schools (red vignettes) due to the construction of roads. Ways are denoted in three radius, the smallest radius being the buffer corresponding to one space kilometer from the way, the second radius corresponding to two space kilometers, and the third radius corresponding to ten space kilometers from the way.

To avoid measurement errors due to concession contract characteristics, for instance, local decisions that change contract characteristics due to political effect or contract terms. I exclude roads under concession in the 1G, 2G, and 5G programs, as well as roads built by INVIAS. Therefore, I compare educational outcomes in schools before and after road construction, loosely controlling for time-varying regional shocks and static differences between schools receiving roads in different years.

In the dynamic difference-in-differences (DiD) method, the DiD approach removes biases in post-intervention comparisons between the treatment and control groups by incorporating pre-existing differences in the groups before treatment, which could be the result of permanent differences between the treated and control groups.

To carry out this exercise, I assume that schools in the treatment and control groups have parallel trends in education outcomes. Schools in Colombia have a positive trend in their school results. I assume that the treatment assignment is not determined by the educational outcome (The main objective of the roads is to connect cities of economic and commercial importance. The intermediate location of the school is therefore exogenous to the outcome). Since not all interventions do not take place in the same period, I use dynamic DiD that allows unifying the treatment period.

I define the period relative to the treatment is denoted in $t = -1$ because the reporting periods of the work were delivered after the saber 11 exams date (Equation 3). I include school fixed effects γ_c for unobserved schooll-specific factors that may have influenced the timing of road construction and time fixed effects σ_t for state-specific policies and shocks that vary by time.

$$\hat{\tau} = S\bar{core}_{beforeroad} - S\bar{core}_{afterroad} \tag{2}$$

$$Score_{c,t,j} = \sum_{\varphi=-S}^{-2} \mu_{\varphi} \cdot D_{c,\varphi} + \sum_{\varphi=0}^{M} \mu_{\varphi} \cdot D_{c,\varphi} + \sigma_t + +\gamma_c + \varepsilon_{c,t} \tag{3}$$

$Score_{c,t,j}$ refers to the potential outcome, specifically is the normalized standard-deviation of the score obtained by the median behavior of the school c in the subject j, in time t. The effect of road construction on education is captured by μ_{φ}. The effect of the road reference the period $t - 1$, considering that the effect of the construction of new roads is estimated with the bandwidth from $-S$ to M. $D_{c,\varphi}$ represent a group of dummie variables that indicate the distance of each period from the treatment period, that is, the period according to the stage in which the road was build.

In this paper I consider other results linked to education. In order to understand the mechanism, I include the results of the effect of the roads construction over **teachers training**, I show evidence of the effects on **human capital accumulation** through the students enrolling in higher studies, I evaluate the effects on **students participation in public and private schools** and, lastly, I evaluate **the students partiticpation in labor force** .

6 Results

I am interested in understanding the effect of road concessions across the all-road stage construction on education. I divide the analysis into two parts. First, I examine the effects on math scores and reading literacy scores. Next, I study impacts on human capital accumulation, student labor force participation, and student participation in private and public schools.

Studies carried out allow establishing the size of the effect on education in interventions. Kraft, 2020 establishes a median impact on education at 0.1 standard deviations (SD). Evans and Yuan, 2022 establishes in a more recent study that impacts on learning (mathematics or reading), the median effect size is 0.10 SD (same to Kraft), with the 25th percentile of 0.01, the 75th percentile of 0.23, and a big effect at 90th percentile is around 0.45 SD.

6.1 Impact of Roads on average results of exam in mathematics and reading literacy

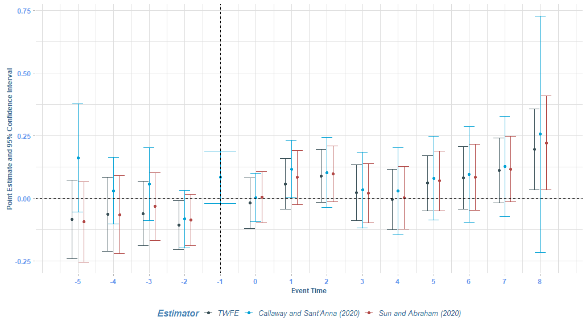
In this section, I show evidence of the effect of road concessions on math and reading literacy scores based on the SABER 11 standardized test. To demonstrate the effect, I use TWFE estimations, and Sun and Abraham, 2021 estimations. The Callaway and Sant'Anna, 2021 estimation is used as a robustness check for the estimation model. I evaluated the dissipation of the effect of roads on education with the estimators of Sun et. al. These results intend to demonstrate that the effect on education is exclusively due to the construction of a road for all periods of construction.

6.1.1 Impact of Roads on average results of exam Saber 11 in mathematics

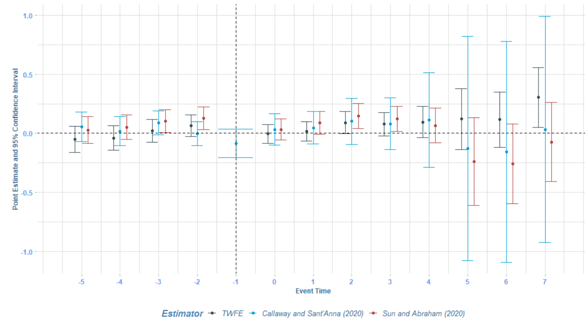
The construction of a road under concession benefits students who study in schools less than a kilometer from the road (see Figure 6.1). When the road construction has reached 10% progress, schools located in an area of less than one kilometer from the road have a maximum effect is observed of 0.22 SD (eight years later). According to the reference time, the year in which the construction of the road has reached 50%, a maximum effect of 0.12 SD is observed (three years later). When the construction of the road is finished, no significant effects are observed on the standardized math scores (see table A.2.1).

Public schools have had a significant and positive effect from the second period after the time relative to treatment, however, private schools do not have any effect. Reading literacy score of affected public schools by the first stage of intervention (10% of advancement) reach an increase of 0.47 SD and 0.32 SD when the road has been finished (100% of advancement), private schools affected when the road has reached the 10% of advancement reached 0.24 SD but dose not any effect after the road has been finished. In mathematics scores, public schools affected by the first stage of construction reach 0.48SD and 0.49 SD when the road construction has finished. (see Figure A.3.1).

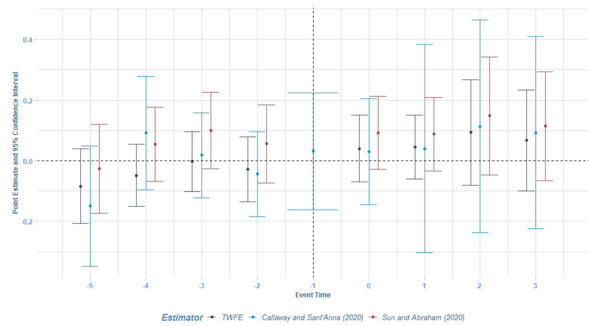
I studied the dissipation of the effect of road construction on math scores. In the final stages of construction, I find an increase in the average math scores only in schools located more than 2,500 meters from the road. For the first stage of construction, I find an increase in the average math in schools located less than 1,500 meters from the road under construction. Figure A.3.2 shows the dissipation of the effect, at different distances from the road and in different stages of construction.



(a) 10 % advance of construction



(b) 50 % advance of construction



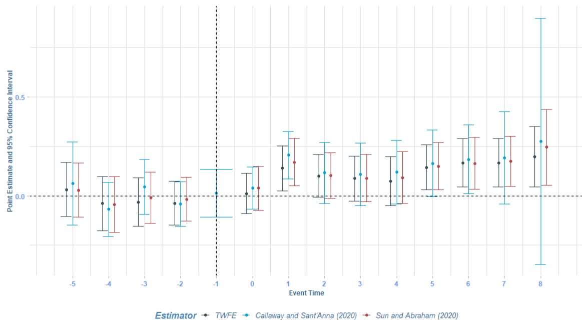
(c) 100 % advance of construction

Figure 6.1: Impact of Roads on average results of exam in mathematics literacy of the last year of secondary education. The treatment time 6.1a is the year in which the construction of the road has reached a ten percent advance the construction, 6.1b is the year in which the construction of the road has reached a fifty percent advance the construction. 6.1c is the year in which the construction of the road has finished.

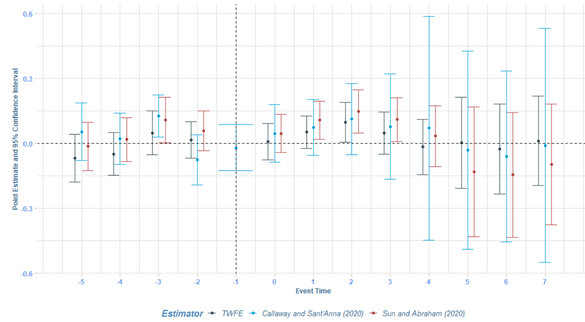
6.1.2 Impact of Roads on average results of exam Saber 11 in reading literacy score

The results on the reading literacy score test are consistent with the results in mathematics based on the advance of construction of 10%, 50% and 100% as treatment time. Schools located in an area of less than one kilometer from the road increase the score in the reading literacy test by 0.25 SD (by Sun and Abraham, 2021 when the road has reached 10% advancement), according to the treatment time related with the year in which the road construction reached 50% the score in reading literacy increase in 0.11 SD. There is no evidence of any effect on the score in the Reading literacy test after the year the road has finished (see Figure 6.2 and table A.2.2).

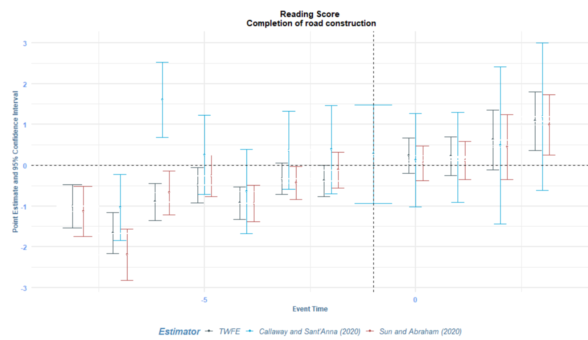
The main effects are on public schools. Public schools increased their average score to 0.45 SD against 0.25 SD in private schools when the road construction reached 10% of



(a) 10 % advance of construction



(b) 50 % advance of construction



(c) 100 % advance of construction

Figure 6.2: Impact of Roads on average results of exam in reading literacy of the last year of secondary education. The treatment time 6.3a is the year in which the construction of the road has reached a ten percent advance the construction. The treatment time 6.3b is the year in which the construction of the road has reached a fifty percent advance the construction. The treatment time 6.3c is the year in which the construction of the road has finished.

advance. Taking as reference the treatment time of the year when the road reached 50% of advance, the score in reading literacy in public schools increased by 0.19 SD and in private schools increased by 0.16 SD. When the road is finished just public schools are affected in 0.324 SD, in private schools there is no evidence of any effect (see Figure A.3.3).

In the Figure A.3.4 I find evidence roads under concession agreement have an impact on reading literacy scores according to the distance in which schools are located from the road. The main effect on schools less one kilometer from the road is given in the first stages of construction. For the last stages of the road construction, the effect expands to schools located more than 2 kilometers away from the road.

6.2 Impact of Roads on human capital accumulation

Human capital accumulation depends on participation in the labor force. If the construction of a road close to a school c generates incentives for students to participate in the labor force, then the fraction of time dedicated to human capital decreasesAcemoglu, 2010, Chapter 10. In this section, I initially show the participation of students in the labor force and then I evaluate the participation of students from the school c who have completed a degree from the university.

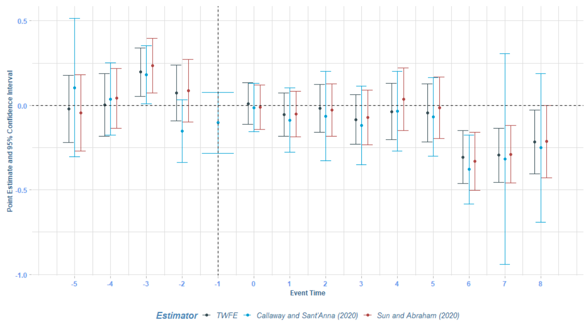
The Ben-Porath model proposed in Acemoglu 2010 Acemoglu, 2010, individuals have innate abilities from the moment of their birth (i.e $h(0) > 0$ where h refers to human capital). A person in his life spends a fraction studying $s(t)$, which implies that the remaining time he spent time on activities such as working ($S(t) = 1 - s(t)$ where $s(t) \in [0, 1] \forall t \geq 0$). A simple version of the human capital accumulation equation takes the form:

$$\dot{h}(t) = \phi(s(t), h(t)) - \delta_h h(t) \tag{4}$$

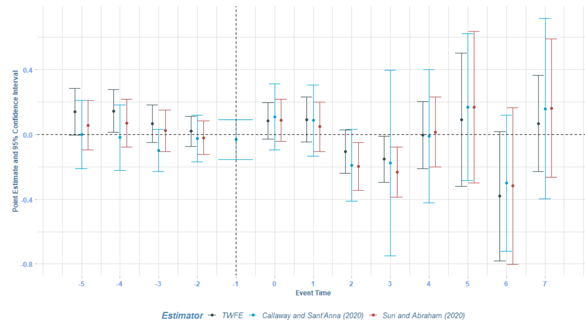
Where $\delta_h h(t)$ captures the depreciation of human capital ($h(t)$). The solution proposed in Acemoglu 2010 Acemoglu, 2010 the Ben-Porath model implies that the accumulation of human capital will be greater if the fraction of study ($s(t)$) is high and the rate of depreciation of human capital is low.

The table A.2.3 show the efect of roads on the fraction of students that participated in the labor force. The fraction of students in labor force decreases according to the first stages of road construction (10% advance) by -0.32 SD, when the road construction reaches 50% the participation of students in the labor force decreases by -0.23 SD. Evaluating the year in which the pathway ends, there is no evidence of effects on the decrease in the labor force. (see Figure 6.3).

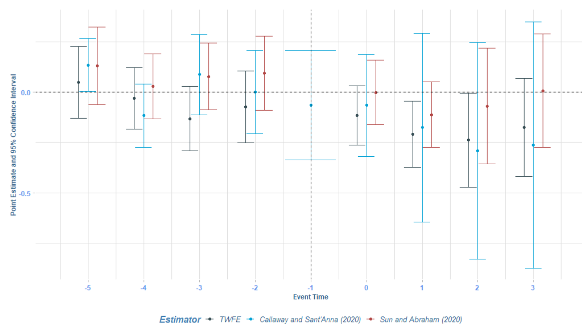
I evaluated the effect of the road concession on the labor force participation in public and private schools. The labor force has a decreasing trend in public schools and I did not find any effect on private schools (see Figure A.3.5). I found evidence of effect of labor participation just at less than two kilometers of distance from the road to the location of the schools (see Figure A.3).



(a) 10 % advance of construction



(b) 50 % advance of construction



(c) 100 % advance of construction

Figure 6.3: Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education. The treatment time 6.3a is the year in which the construction of the road has reached a ten percent advance the construction. The treatment time 6.3b is the year in which the construction of the road has reached a fifty percent advance the construction. The treatment time 6.3c is the year in which the construction of the road has finished.

I found that the fracion of students who participate in university studies increase in a 0.14 SD by the effect of first stage of construction (Sun and Abraham estiamtion) A.2. The lack of current information and the eventuality of COVID-19 does not allow calculating the effect in more future periods. Since these situations changed the dynamics of study from the year 2020 and 2022.

7 Conclusions

I quantify the effect of road intervention under a concession contract on education in Colombia. The evaluation of education was carried out in relation to the results in standardized tests of mathematics and language. Evaluated the effect on participation in the labor force and on the fraction of students who complete a university degree. Finally, I evaluate the existing heterogeneities between public and private schools.

The main results from the dynamic difference-in-differences estimation (Sun and Abraham, 2021) show that schools near a road that has been intervened under a concession agreatment increase the average result in mathematics and reading literacy of students in the last year of secondary school.

The effect of the intervention of a road under a concession contract is a shock wave effect. In the first stages of intervention, schools closest to the road are the ones affected, as the time of intervention progresses, the effect reaches schools more than one kilometer from the road and stops affecting schools less than one kilometer from the road. kilometer.

In the final stages of intervention, I find an increase of 0.34 SD in the average math scores and 0.44 in reading literacy at schools located more than 2,500 meters from the road. For the first stage of construction, I find an increase in the average math of 0.22 SD and 0.25 at schools located less than 1,500 meters from the road under construction.

I found evidence that intervention of road on school increase the fraction of students who complete a university degree increases of 25% (i.e. After the intervention, 25 of every 100 students of a school who claimed to work, no longer do). In the same way, schools increased in 13% the fraction of students with a university degree.

Finally, I find evidence that public schools are seen to achieve greater benefits than public schools.

References

A. Chevalier, Gauthier Lanot. (2002). The Relative Effect of Family Characteristics and Financial Situation on Educational Achievement.

Acemoglu, D. (2010). Daron acemoglu, introduction to modern economic growth, princeton, princeton university press, 2009, 990 pp., 359–384.

Adukia, A., Asher, S., & Novosad, P. (2020). Educational investment responses to economic opportunity: Evidence from Indian road construction. *American Economic Journal: Applied Economics*, *12*(1), 348–376. https://doi.org/10.1257/app.20180036

Asher, S., & Novosad, P. (2020). Birural roads and local economic development. *American Economic Review*, *110*(3), 797–823. https://doi.org/10.1257/aer.20180268

Atack, J., & Margo, R. A. (2011). The impact of access to rail transportation on agricultural improvement: The american midwest as a test case, 1850–1860. *Journal of Transport and Land Use*, *4*(2), 5–18. Retrieved September 6, 2022, from http://www.jstor.org/stable/26201667

Berg Claudia N, D. U. K. e. a. (2015). *Transport policies and development*. The World Bank.

Burgess, R., & Donaldson, D. (2014). Railroads and the demise of famine in colonial india.

Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods [Themed Issue: Treatment Effect 1]. *Journal of Econometrics*, *225*(2), 200–230. https://doi.org/https://doi.org/10.1016/j.jeconom.2020.12.001

Datta, S. (2012). The impact of improved highways on indian firms. *Journal of Development Economics*, *99*(1), 46–57. https://doi.org/https://doi.org/10.1016/j.jdeveco.2011.08.005

Donaldson, D. (2018). Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review*, *108*(4-5), 899–934. https://doi.org/10.1257/aer.20101199

Emran, M. S., & Hou, Z. (2013). Access to Markets and Rural Poverty: Evidence from Household Consumption in China. *The Review of Economics and Statistics*, *95*(2), 682–697. https://doi.org/10.1162/REST_a_00354

Emran, M. S., & Shilpi, F. (2012). The extent of the market and stages of agricultural specialization. *The Canadian Journal of Economics / Revue canadienne d'Economique*, *45*(3), 1125–1153. Retrieved September 6, 2022, from http://www.jstor.org/stable/23270575

Evans, D. K., & Popova, A. (2016). What Really Works to Improve Learning in Developing Countries? An Analysis of Divergent Findings in Systematic Reviews. *The World Bank Research Observer*, *31*(2), 242–270. https://doi.org/10.1093/wbro/lkw004

Evans, D. K., & Yuan, F. (2022). How big are effect sizes in international education studies?

Faber, B. (2014). Trade Integration, Market Size, and Industrialization: Evidence from China's National Trunk Highway System. *The Review of Economic Studies*, *81*(3), 1046–1070. https://doi.org/10.1093/restud/rdu010

Fernald, J. G. (1999). Roads to prosperity? Assessing the link between public capital and productivity. *American Economic Review*, *89*(3), 619–638. https://doi.org/10.1257/aer.89.3.619

Fernández, J., Guerra, J. A., & Mohnen, M. (2020). Train to Opportunity: the Effect of Infrastructure on Intergenerational Mobility. *SSRN Electronic Journal*, 1–85. https://doi.org/10.2139/ssrn.3751814

Ghani, E., Goswami, A. G., & Kerr, W. R. (2015). Highway to Success: The Impact of the Golden Quadrilateral Project for the Location and Performance of Indian Manufacturing. *The Economic Journal*, *126*(591), 317–357. https://doi.org/10.1111/ecoj.12207

Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics*, *57*(1), 148–169. https://doi.org/https://doi.org/10.1016/j.jue.2004.10.002

H. Hanson, G. (2005). Market potential, increasing returns and geographic concentration. *Journal of International Economics*, *67*(1), 1–24. https://doi.org/https://doi.org/10.1016/j.jinteco.2004.09.008

Head, K., & Mayer, T. (2011). Gravity, market potential and economic development. *Journal of Economic Geography*, *11*(2), 281–294. https://ideas.repec.org/a/oup/jecgeo/v11y2011i2p281-294.html

Hong, K., & Zimmer, R. (2016). Does Investing in School Capital Infrastructure Improve Student Achievement? *Economics of Education Review*, *53*, 143–158. https://doi.org/10.1016/j.econedurev.2016.05.007

Howard White, S. S. (2014). Quasi-experimental design and methods: Methodological briefs - impact evaluation. *UNICEF Office of Research Methodological Briefs*. https://www.unicef-irc.org/publications/753-quasi-experimental-design-and-methods-methodological-briefs-impact-evaluation-no.html

Idei, R., Kato, H., & Morikawa, S. (2020). Contribution of rural roads improvement on children's school attendance: Evidence in Cambodia. *International Journal of Educational Development*, *72*, 102131. https://doi.org/10.1016/j.ijedudev.2019.102131

J. Blanden, Paul Gregg. (2004). Family income and educational attainment: a review of approaches and evidence for Britain.

J. Isernhagen & N. Bulkin. (n.d.). The Impact of Mobility on Student Performance and Teacher Practice.

Jong-Wha Lee, R. Barro. (1997). Schooling Quality in a Cross Section of Countries.

Josh Kinsler, Ronni Pavan. (2011). Family Income and Higher Education Choices: The Importance of Accounting for College Quality.

Kathryn Wilson. (2002). The effects of school quality on income.

Khumalo, B., & Mji, A. (2014). Exploring Educators' Perceptions of the Impact of Poor Infrastructure on Learning and Teaching in Rural South African Schools. *Mediterranean Journal of Social Sciences*. https://doi.org/10.5901/mjss.2014.v5n20p1521

Kraft, M. A. (2020). Interpreting effect sizes of education interventions. *Educational Researcher*, *49*(4), 241–253. https://journals.sagepub.com/doi/full/10.3102/0013189X20912798

L. Musyoka. (n.d.). Influence of provision of school physical infrastructure on students' performance in Kenya certificate of secondary education in Mwingi central district, Kenya.

Mukherjee, M. (2012). Do Better Roads Increase School Enrollment? Evidence from a Unique Road Policy in India. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2207761

Muñoz Prieto, W. (2002). Concesiones viales en colombia. historia y desarrollo. *Tecnura*, *5*(10), 18–26. https://doi.org/10.14483/22487638.5883

N. Dragutinovic & D. Twisk. (n.d.). The Effectiveness Of Road Safety Education. A Literature Review.

Paul Gregg, L. Macmillan. (2009). Family Income and Education in the Next Generation: Exploring income gradients in education for current cohorts of youth.

Quintero, L., & Sinisterra, G. (WP2022). *Long and Winding Roads : Roads , Inequality , and Growth in Colombia .*

S. Raftery & L. Wundersitz. (n.d.). The efficacy of road safety education in schools: A review of current approaches.

Sanchez, N. (2022). *Documentary interview about road concessions in colombia.*

Sanchis-Guarner, R. (2012). *Driving Up Wages: The Effects of Road Construction in Great Britain* (SERC Discussion Papers No. 0120). Centre for Economic Performance, LSE. https://ideas.repec.org/p/cep/sercdp/0120.html

Sun, L., & Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects [Themed Issue: Treatment Effect 1]. *Journal of Econometrics*, *225*(2), 175–199. https://doi.org/https://doi.org/10.1016/j.jeconom.2020.09.006

Tao Lin, Han Lv. (2017). The effects of family income on children ' s education : An empirical analysis of CHNS data.

Yasar Avsar, T. G. (2004). Determination of safe distance between roadway and school buildings to get acceptable school outdoor noise level by using noise barriers.

Zipporah M Mokaya. (n.d.). Influence Of School Infrastructure On Students' Performance In Public Secondary Schools In Kajiado County, Kenya.

A Appendix

A.1 Descriptive Statistics

	Average results by school		
Buffer distance from the road	1 Km	2 Km	10 Km
Panel All data			
Score Math	0.451 (0.118)	0.455 (0.132)	0.474 (0.119)
Score Reading literacy	0.498 (0.087)	0.438 (0.087)	0.472 (0.101)
N	144	217	890
Panel Treated schools			
Score Math	0.402 (0.063)	0.407 (0.065)	0.441 (0.067)
Score Reading literacy	0.432 (0.057)	0.438 (0.065)	0.472 (0.067)
N	99	66	292
Panel Control schools			
Score Math	0.435 (0.07)	0.44 (0.069)	0.424 (0.07)
Score Reading literacy	0.458 (0.055)	0.461 (0.053)	0.449 (0.061)
N	45	151	598

The table indicates the mean and in parenthesis the standar desviation of the indicator. It presents for all the panel data, treated schools and control schools the average results in maths and reading scores and the size of the sample where the sample vary by the distance between the roads and the schools as it is shown in the columns.

A.2 Table results

The results of the mathematics score for all the different stages of construction are found in table A.2.1, these estimation are based on Sun and Abraham, 2021 estimation.

Table A.2.1. Mathematics score for all the different stages of construction.

Dependent Variable:	score in mathematics		
Model by level of construction :	10 % advance	50 % advance	100 % advance
Variables			
year = -8	-0.0149	0.0173	-0.0844
	(0.2195)	(0.0804)	(0.0676)
year = -7	0.2077	0.0208	-0.0026
	(0.1964)	(0.0699)	(0.0734)
year = -6	-0.2923***	-0.0347	0.0872
	(0.1077)	(0.0587)	(0.0760)
year = -5	-0.0940	0.0280	-0.0266
	(0.0818)	(0.0583)	(0.0747)
year = -4	-0.0654	0.0510	0.0550
	(0.0796)	(0.0532)	(0.0624)
year = -3	-0.0328	0.1018**	0.0997
	(0.0691)	(0.0494)	(0.0640)
year = -2	-0.0873*	0.1275***	0.0562
	(0.0520)	(0.0484)	(0.0658)
year = 0	0.0039	0.0319	0.0926
	(0.0518)	(0.0455)	(0.0616)
year = 1	0.0830	0.0869*	0.0878
	(0.0549)	(0.0494)	(0.0619)
year = 2	0.0967*	0.1465***	0.1478
	(0.0568)	(0.0537)	(0.0993)
year = 3	0.0200	0.1227**	0.1142
	(0.0605)	(0.0548)	(0.0915)
year = 4	0.0018	0.0667	
	(0.0642)	(0.0744)	
year = 5	0.0695	-0.2395	
	(0.0607)	(0.1893)	
year = 6	0.0843	-0.2568	
	(0.0674)	(0.1723)	
year = 7	0.1164*	-0.0735	
	(0.0671)	(0.1711)	
year = 8	0.2204**		
	(0.0958)		
Fixed-effects			
id_name	Yes	Yes	Yes
year	Yes	Yes	Yes
Fit statistics			
Observations	5,882	5,882	5,843
R^2	0.73786	0.73699	0.73070
Within R^2	0.01476	0.01370	0.00849

Clustered (id_name) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The table indicates the mean estimation effect and in parenthesis the standar desviation on mathematic scores. The columns clasify the results by the percetanje of completeness. The rows clasify the results acording to the year relative to the intervention. The last rows present the fit statistics.

The results of the Reading literacy score for all the different stages of construction are found in table A.2.2, these estimation are based on Sun and Abraham, 2021 estimation.

Table A.2.2 Reading literacy score for all the different stages of construction

Dependent Variable:	Reading literacy		
Model by level of construction :	10 % advance	50 % advance	100 % advance
Variables			
year = -8	-0.3852**	-0.0521	-0.0552
	(0.1915)	(0.0651)	(0.0608)
year = -7	0.2824***	-0.0701	-0.1408**
	(0.1017)	(0.0594)	(0.0635)
year = -6	-0.0934	-0.0622	0.0795
	(0.0919)	(0.0596)	(0.0693)
year = -5	0.0283	-0.0131	0.0293
	(0.0702)	(0.0571)	(0.0630)
year = -4	-0.0446	0.0176	0.0857
	(0.0714)	(0.0523)	(0.0590)
year = -3	-0.0094	0.1078**	0.0621
	(0.0666)	(0.0540)	(0.0558)
year = -2	-0.0173	0.0580	0.1121*
	(0.0568)	(0.0465)	(0.0584)
year = 0	0.0381	0.0459	0.1219**
	(0.0562)	(0.0453)	(0.0551)
year = 1	0.1691***	0.1074**	0.0841
	(0.0611)	(0.0452)	(0.0526)
year = 2	0.1027*	0.1474***	0.0630
	(0.0587)	(0.0506)	(0.0735)
year = 3	0.0888	0.1097**	-0.0247
	(0.0610)	(0.0519)	(0.0718)
year = 4	0.0917	0.0335	
	(0.0666)	(0.0718)	
year = 5	0.1497**	-0.1309	
	(0.0615)	(0.1534)	
year = 6	0.1640**	-0.1449	
	(0.0666)	(0.1471)	
year = 7	0.1752***	-0.0966	
	(0.0643)	(0.1423)	
year = 8	0.2455**		
	(0.0982)		
Fixed-effects			
id_name	Yes	Yes	Yes
year	Yes	Yes	Yes
Fit statistics			
Observations	5,882	5,882	5,843
R^2	0.74701	0.74888	0.74911
Within R^2	0.01748	0.01502	0.00854

Clustered (id_name) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The table indicates the mean estimation effect and in parenthesis the standar desviation on reading scores. The columns clasify the results by the percetanje of completeness. The rows clasify the results acording to the year relative to the intervention. The last rows present the fit statistics.

The results of the Reading literacy score for all the different stages of construction are found in table A.2.3, these estimates are based on Sun and Abraham, 2021 estimation.

Table A.2.3 Fraction of students who participate in labor force for all the different stages of construction

Dependent Variable:	Fraction of students who participate in labor force		
Model by level of construction :	10 % advance	50 % advance	100 % advance
Variables			
year = -8	0.3341*	0.0429	0.1899*
	(0.1894)	(0.0866)	(0.0966)
year = -7	0.1566	0.3807***	-0.0574
	(0.3387)	(0.0985)	(0.0787)
year = -6	0.0765	0.0685	0.0028
	(0.1561)	(0.0815)	(0.0843)
year = -5	-0.0458	0.0578	0.1307
	(0.1150)	(0.0788)	(0.0986)
year = -4	0.0415	0.0709	0.0286
	(0.0910)	(0.0756)	(0.0820)
year = -3	0.2354***	0.0228	0.0773
	(0.0819)	(0.0653)	(0.0846)
year = -2	0.0879	-0.0199	0.0933
	(0.0945)	(0.0528)	(0.0941)
year = 0	-0.0100	0.0872	-0.0015
	(0.0670)	(0.0661)	(0.0812)
year = 1	-0.0506	0.0482	-0.1120
	(0.0687)	(0.0779)	(0.0829)
year = 2	-0.0279	-0.1970***	-0.0700
	(0.0790)	(0.0759)	(0.1469)
year = 3	-0.0699	-0.2323***	0.0070
	(0.0825)	(0.0784)	(0.1439)
year = 4	0.0377	0.0151	
	(0.0947)	(0.1105)	
year = 5	-0.0143	0.1681	
	(0.0922)	(0.2386)	
year = 6	-0.3295***	-0.3180	
	(0.0876)	(0.2464)	
year = 7	-0.2900***	0.1621	
	(0.0868)	(0.2181)	
year = 8	-0.2143**		
	(0.1088)		
Fixed-effects			
id_name	Yes	Yes	Yes
year	Yes	Yes	Yes
Fit statistics			
Observations	5,882	5,882	5,843
R^2	0.47454	0.47006	0.46806
Within R^2	0.03010	0.02145	0.00789

Clustered (id_name) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The table indicates the mean estimation effect and in parenthesis the standar desviation on labor force. The columns clasify the results by the percetanje of completeness. The rows clasify the results acording to the year relative to the intervention. The last rows present the fit statistics.

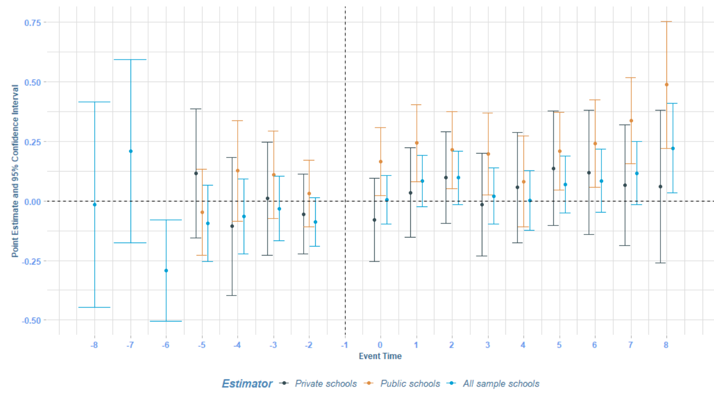
Table A.2.4 Fraction of students that finished some university level for all the different stages of construction

Dependent Variable:	Fraction of students that finished some university level	
Model by level of construction :	10 % advance	50 % advance
Variables		
year = -3	0.0016	-0.1275
	(0.0499)	(0.1112)
year = -2	0.0525	0.0038
	(0.0521)	(0.1437)
year = 0	0.0946^{*}	-0.2892
	(0.0523)	(0.1876)
year = 1	0.1415^{***}	0.1260
	(0.0534)	(0.1359)
year = 2	0.1342^{**}	
	(0.0633)	
Fixed-effects		
id_name	Yes	Yes
year	Yes	Yes
Fit statistics		
Observations	3,101	3,101
R^2	0.67737	0.66500
Within R^2	0.00350	0.00206

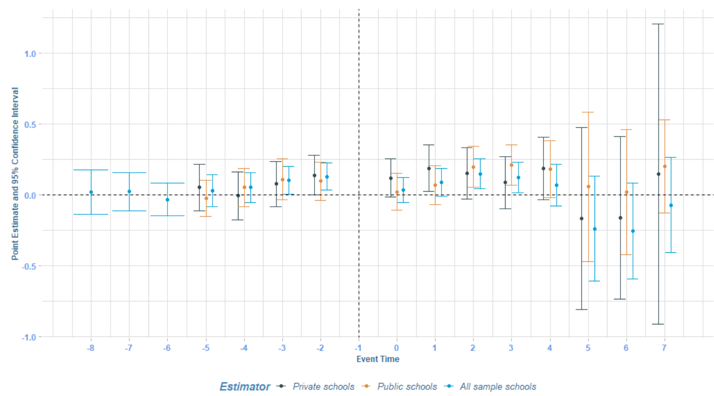
Clustered (id_name) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The table indicates the mean estimation effect and in parenthesis the standar desviation on the fraction of students that finished some univeristy level. The columns clasify the results by the percetanje of completeness. The rows clasify the results acording to the year relative to the intervention. The last rows present the fit statistics.

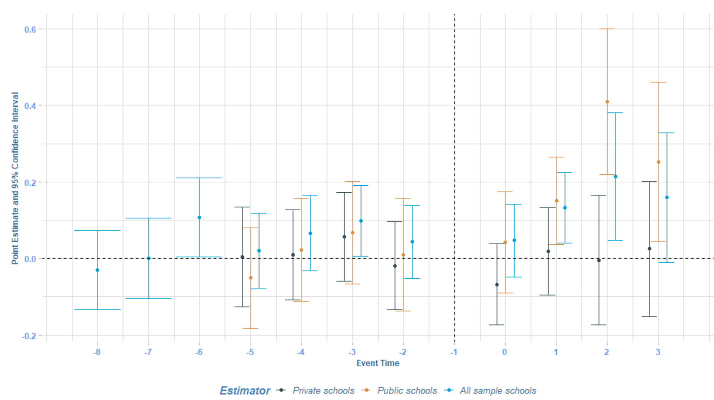
A.3 Otros resultados



(a) 10 % advance of construction

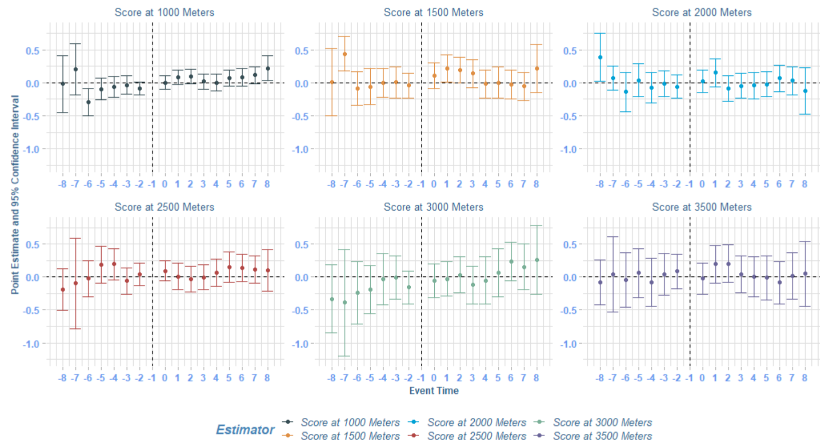


(b) 50 % advance of construction

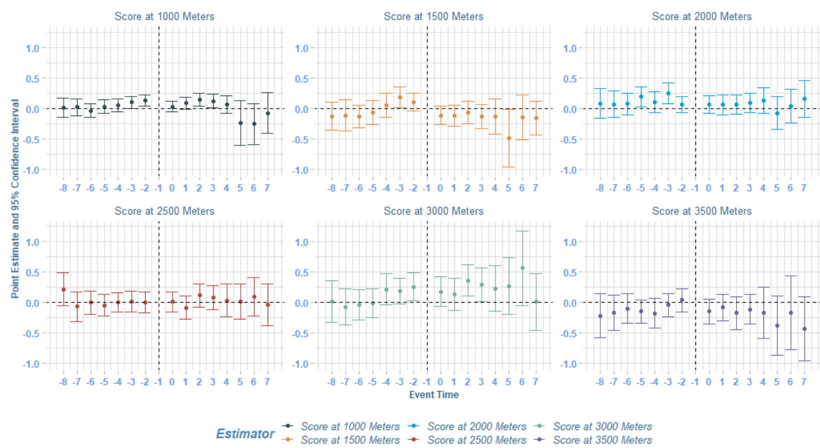


(c) 100 % advance of construction

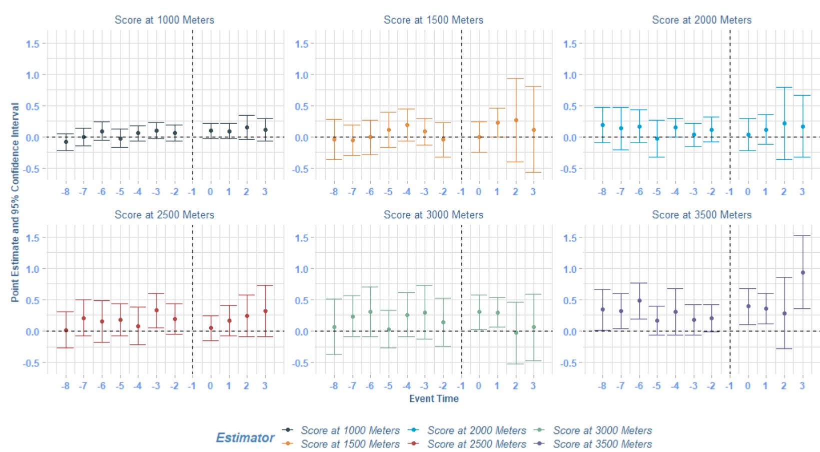
Figure A.3.1: Estimation of heterogeneities (Sun and Abraham, 2021 estimator) in mathematics results according to the nature of the school



(a) 10 % advance of construction

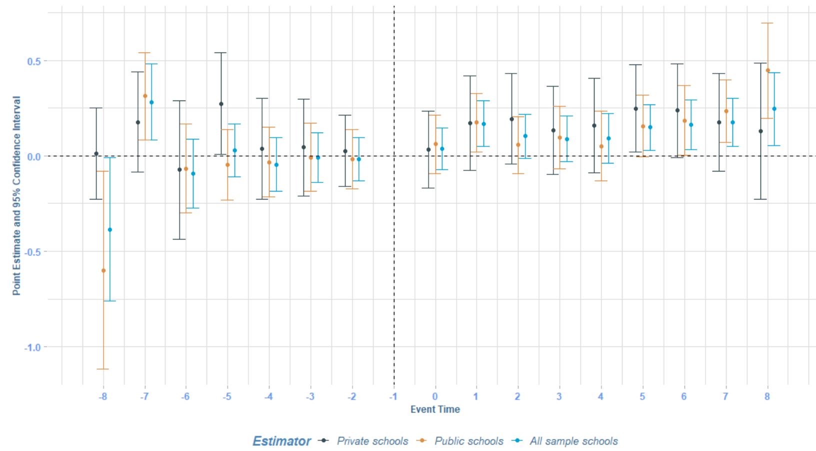


(b) 50 % advance of construction

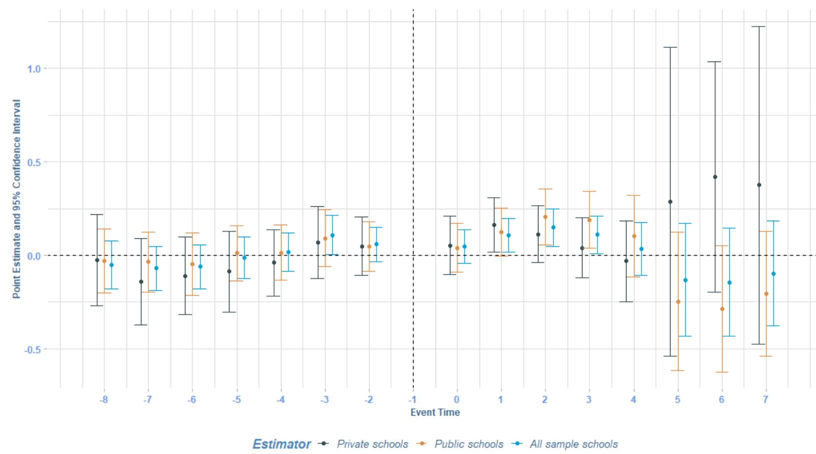


(c) 100 % advance of construction

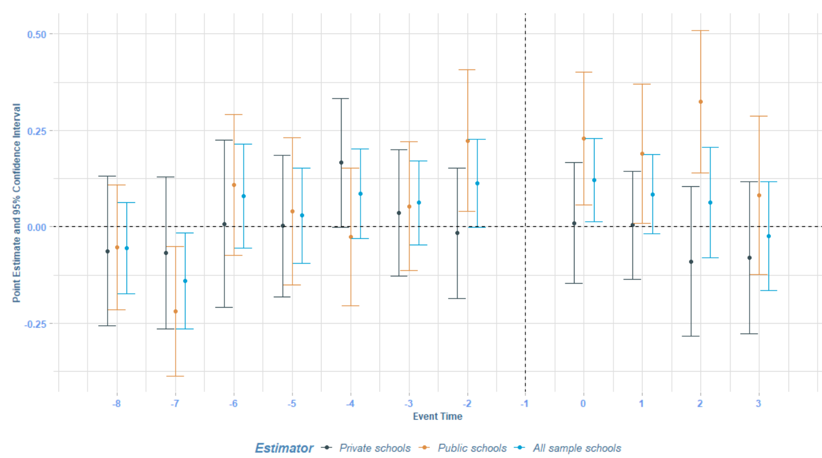
Figure A.3.2: Impact of road construction on math score by distance of school from road in Math Result



(a) 10 % advance of construction

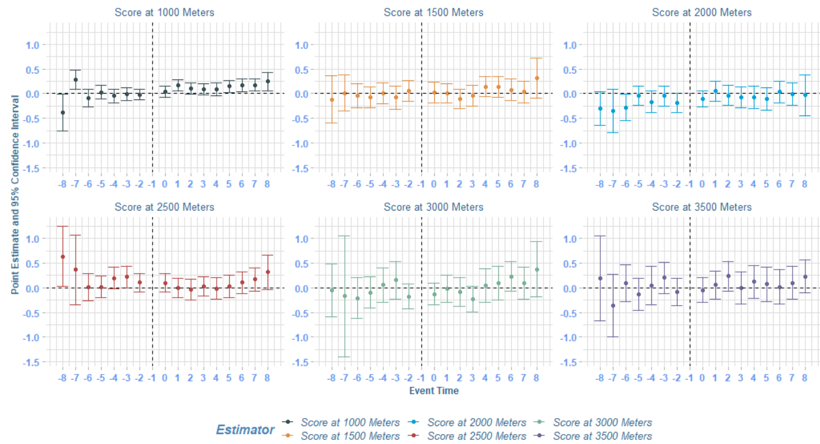


(b) 50 % advance of construction

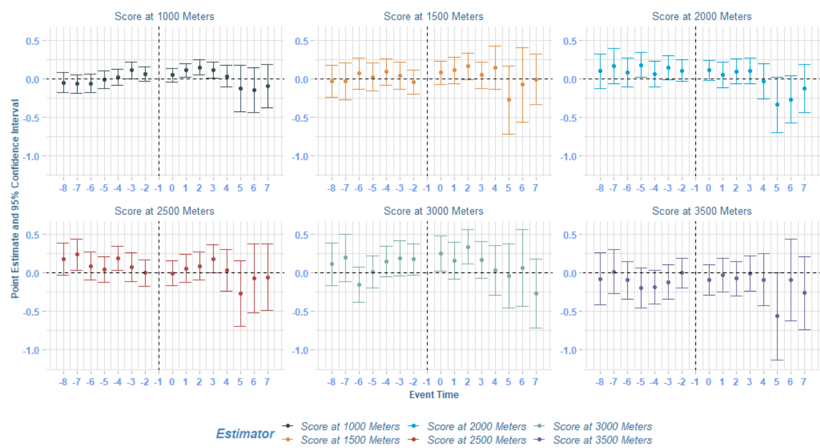


(c) 100 % advance of construction

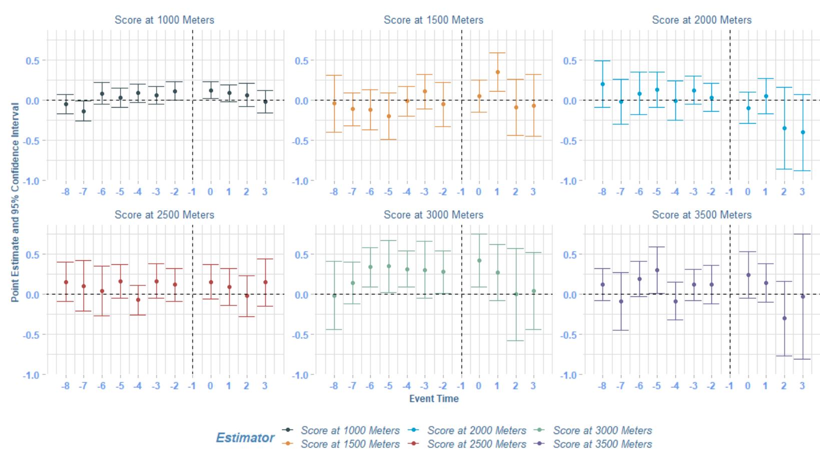
Figure A.3.3: Heterogeneities in reading literacy score of students by nature of the school



(a) 10 % advance of construction

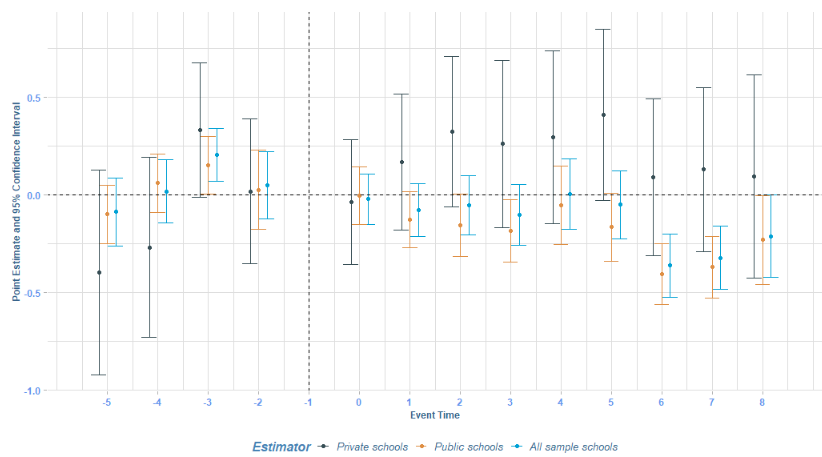


(b) 50 % advance of construction

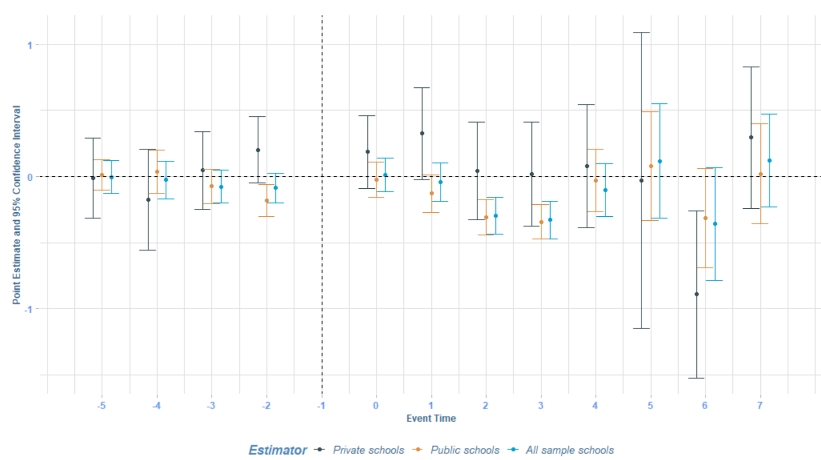


(c) 100 % advance of construction

Figure A.3.4: Impact of road construction on reading literacy score by distance of school from road

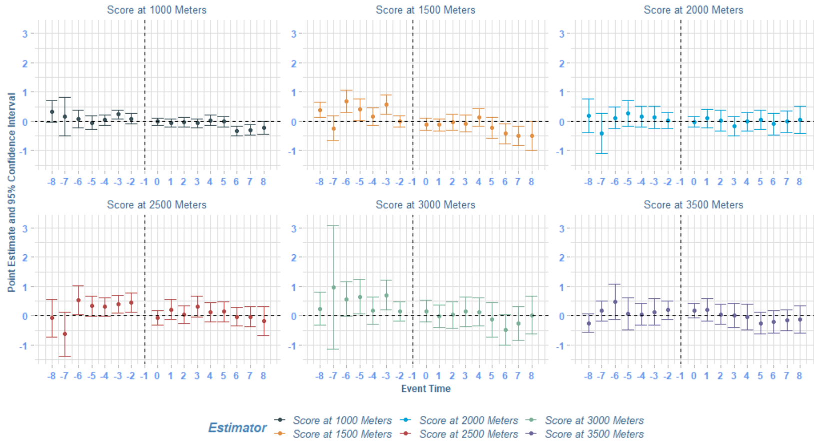


(a) 10 % advance of construction

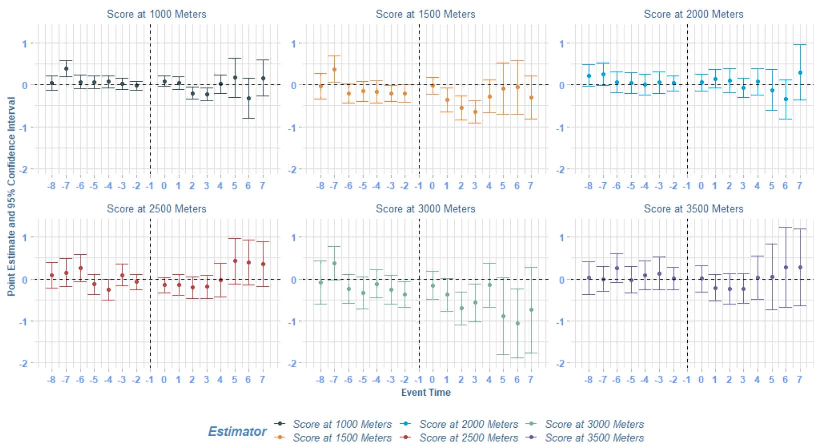


(b) 50 % advance of construction

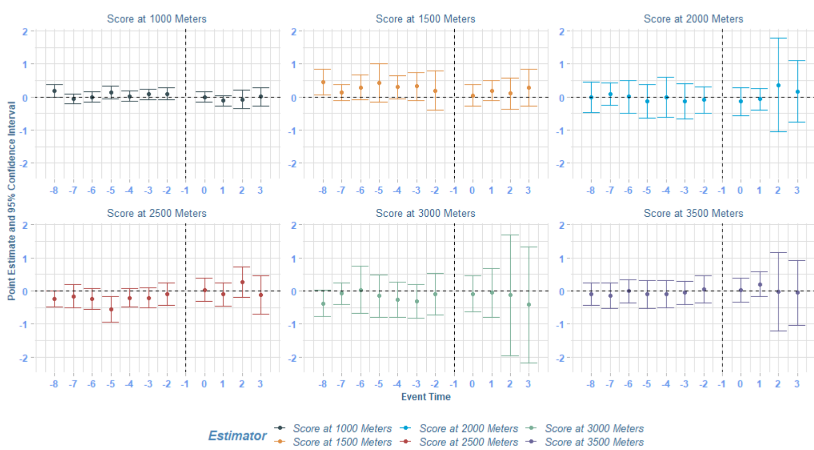
Figure A.3.5: Heterogeneities of fraction of students in labor force by nature of the school



(a) 10 % advance of construction



(b) 50 % advance of construction



(c) 100 % advance of construction

Figure 13: Impact of road construction on school share of labor force participation by distance of school from road.