

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

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IEA World Congress 2023

December 14, 2023

Colombian Context

1. In 1997, road concessions were born in Colombia, in response to the lack of state resources for investment in the National Road Network.
2. In a road concession, the state entity grants a concessionaire the responsibility for:
 - i. The construction or improvement of a road
 - ii. Operation, exploitation, and management of a road,
 - iii. Collect tolls from road users
3. On average the time required for reaching the **10%** advance is 7.25 years and 2 years more for reaching the **50%** of advance of the road and 13 years to get be finished.
4. The concession length had an average of **191 km**
 - i. The shortest concession length was **31km**.
 - ii. The largest concession length was **491 km**.
5. 987 schools (Public 737, Private 250) were implicated within a radius of 1000 meters from the road which represents the focus of this research.

See a road concessions.

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3 Hypothesis of Mechanisms

4 Results

- Results in mathematics
- Results in reading literacy
- Results in university participation

5 Conclusion

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Why I did this.

In Colombia, Approximately 27% of schools are located more than 5 kilometer away from a paved road that allows vehicular land traffic 24 hours a day, 365 days a year (13% between 5 and 10 Km, 9% between 10 and 20 Km and 5% at more than 20 Km).

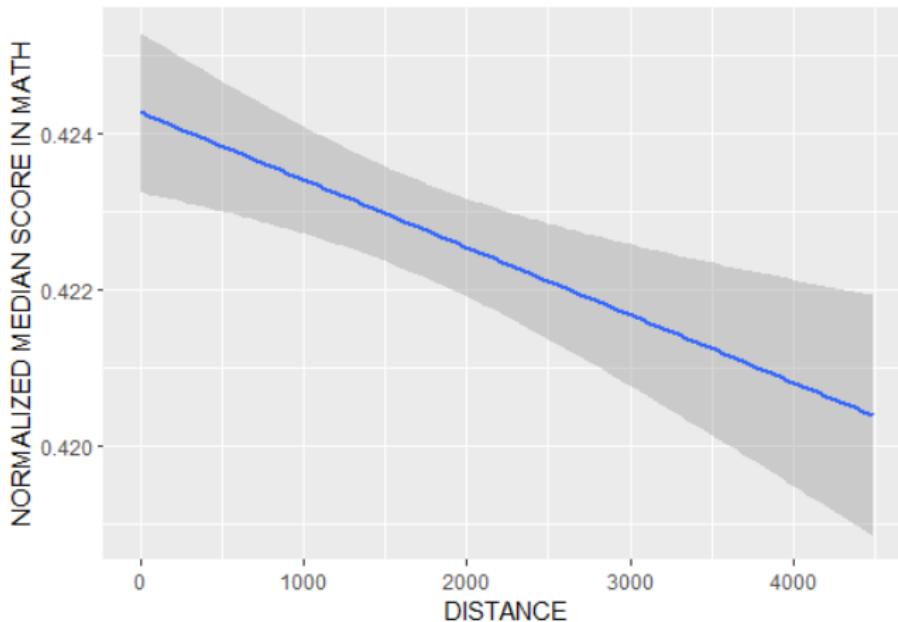


Figure: Correlation between distance and math scores

This paper.

Question: What is the impact of roads under a concession contract on education in Colombia?

- ① DiD in dynamic time (Sun et al. 2020) estimation to identify the causal effect of roads on education in Colombia.
 - i. Academic performance: ↑ Math score, ↑ Reading literacy score.
 - ii. Heterogeneities by nature of school: ↑ public schools, ✗ private schools.
- ② A road could impact education through multiple mechanisms.
 - i. Labor Force: ↓ Participation of students in labor force.
 - ii. Teacher training: ↑ Proportion of teachers with university education.
 - iii. Family income: ✗ ✗ Family income of the student.
- ③ Robustness check
 - i. If potential outcomes are random, then I have randomized experiments.
 - ii. If the road is the precursor to an impact on education then there should be no effect during COVID-19 (Remote studies).
 - iii. Spatial and Temporal tests where used in this study.

This study contribute to the literature showing **evidence that road concession agreements in Colombia impacts education** in the following outcomes:

- Road infrastructure leads to increased attendance, completion of studies, school enrollment, and performance on exams¹.
 - Road infrastructure significantly influences education choices².

¹See, for example Aparicio 2020 et al., Adukia 2017 et al., Singh 2017 et al.

²See, for example Adukia 2020, Edmonds et al. 2006, Edmonds et al. 2010 and Shastry 2012.

This study contribute to the literature showing evidence that road concession agreements in Colombia impacts education in the following outcomes:

- Road infrastructure leads to increased attendance, completion of studies, school enrollment, and performance on exams³.
 - ▶ I found heterogeneous effects on private and public schools.
 - Road infrastructure significantly influences education choices⁴.
 - ▶ I found an effect on labor force participation of students in the last year of secondary.

³See, for example Aparicio 2020 et al., Adukia 2017 et al., Singh 2017 et al.

⁴See, for example Adukaia 2020, Edmonds et al. 2006, Edmonds et al. 2010 and Shastry 2012.

How?

Data

This study was carried through the following Colombian administrative data:

- General results and survey of the standardized exam of the last year of high school called Saber 11. (2006-2020) Education
- General results of the state test for the last semesters post-secondary education students, called Saber pro (2006-2021).
- Vector of roads databases in Colombia. (2011-2019)
- Vector of schools databases in Colombia (DANE).
- Electronic survey of formal education – EDUC (C600).
- Road concession agreements and annual progress reports.

Treated and Control

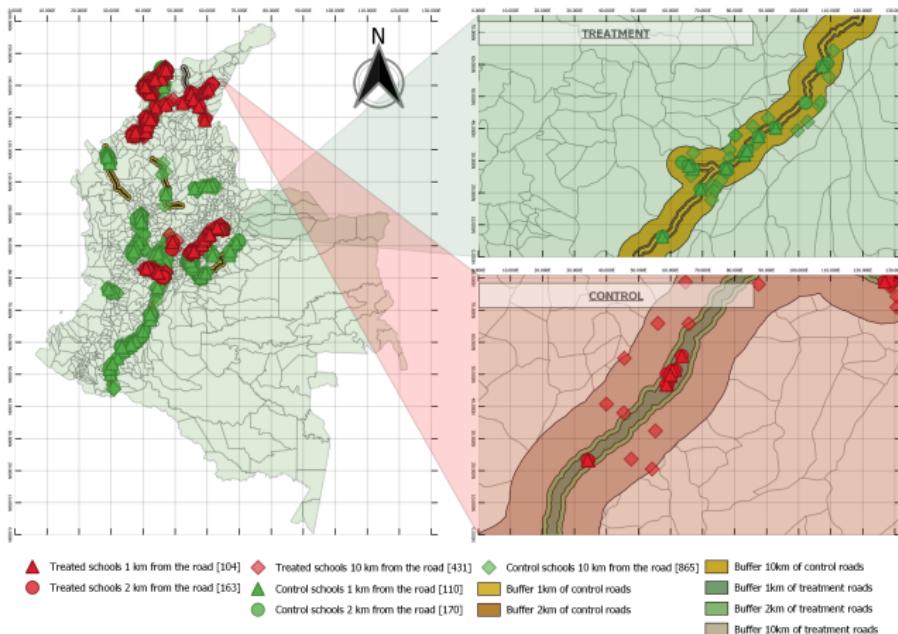


Figure: Location of schools treated (green vignettes) and control schools (red vignettes) due to the construction of roads. Ways are denoted in three radii, the smallest radius being the buffer corresponding to one space kilometer from the way, the second radius corresponding to two space kilometers,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

[Appendix!](#)

Specification

$$\hat{\tau} = \bar{Score}_{before road} - \bar{Score}_{after road} \quad (1)$$

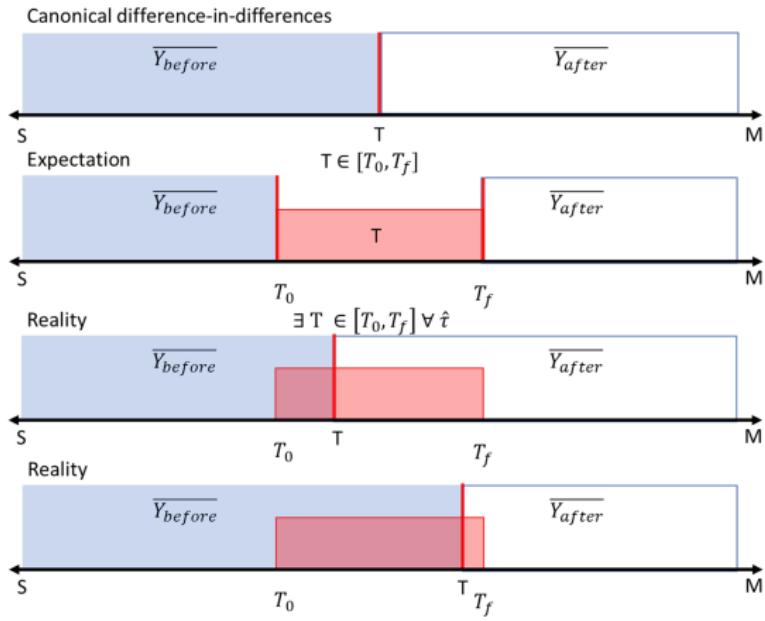
$$Score_{c,t,j}^{\varphi} = \sum_{\tau=-S}^{-2} \mu_{\tau} \cdot D_{c,\tau} + \sum_{\tau=0}^M \mu_{\tau} \cdot D_{c,\tau} + \sigma_t + \gamma_c + \varepsilon_{c,t} \quad (2)$$

Where:

- $t = -1$ Period relative to the treatment.
- γ_c School fixed effects.
- σ_t time fixed effects.
- $Score_{c,t,j}$ Is the outcome.
- μ_{φ} Is the effect of road construction on education.
- The effect of the construction of new roads is estimated with the bandwidth from $-S$ to M .
- $D_{c,\varphi}$ Represent a group of dummy variables that indicate the distance of each period from the treatment period.

Estimation problem.

$$\hat{\tau} = \overline{Y_{after}} - \overline{Y_{before}}$$



Effect size of Results

	Effect size						
	Overall		Math		Reading		Enrollment
Effect size	sd^1	sd^2	sd^1	sd^2	sd^1	sd^2	sd^1
Small	0.08	0.04	0.05	0.08	0.03	0.08	0.03
Moderate	0.1	0.1	0.07	0.07	0.14	0.12	0.06
Large	0.45	0.47	0.31	0.37	0.5	0.5	0.38
Number of studies	96	747	199	314	269	495	33

Note: sd^1 refers to the studies carried out by Evans, 2022 and sd^2 refers to the studies carried out by Kraft, 2020. The distribution of sample size is based on all RCT studies

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Results in math test.

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Estimation of heterogeneities (Sun and Abraham, 2021 estimator) in mathematics results according to the nature of the school

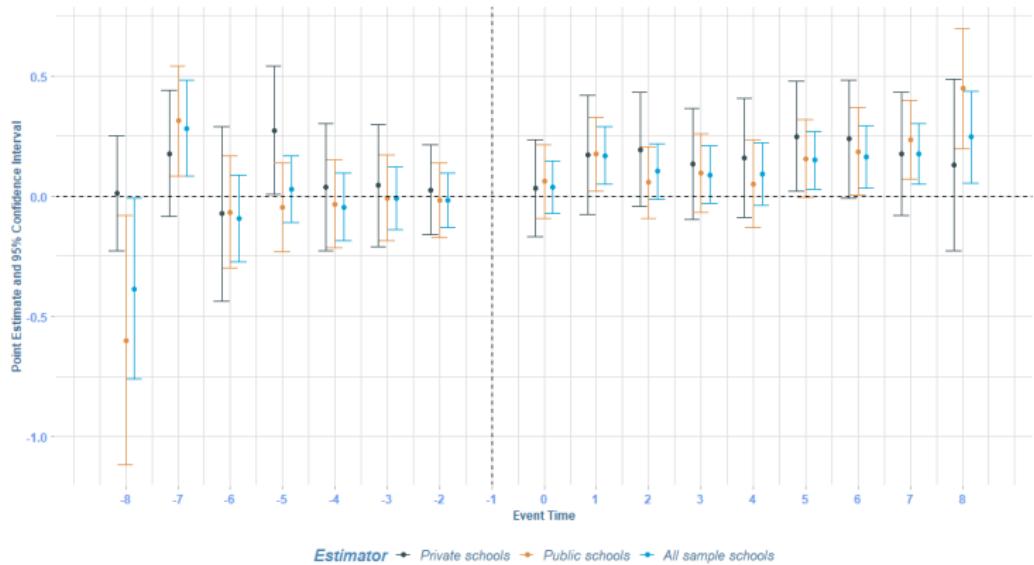


Figure: 10 % advance of construction

Mathematics score for all the different stages of construction

Dependent Variable:	score in mathematics					
Model by level of construction :	10 %	graph!	50 %	graph!	100 %	graph!
<i>Variables</i>						
year = -8	-0.0149 (0.2195)		0.0173 (0.0804)		-0.0844 (0.0676)	
year = -7	0.2077 (0.1964)		0.0208 (0.0699)		-0.0026 (0.0734)	
year = -6	-0.2923 (0.1077)		-0.0347 (0.0587)		0.0872 (0.0760)	
year = -5	-0.0940 (0.0818)		0.0280 (0.0583)		-0.0266 (0.0747)	
year = -4	-0.0654 (0.0796)		0.0510 (0.0532)		0.0550 (0.0624)	
year = -3	-0.0328 (0.0691)		0.1018 (0.0494)		0.0997 (0.0640)	
year = -2	-0.0873 (0.0520)		0.1275 (0.0484)		0.0562 (0.0658)	
year = 0	0.0039 (0.0518)		0.0319 (0.0455)		0.0926 (0.0616)	
year = 1	0.0830 (0.0549)		0.0869 (0.0494)		0.0878 (0.0619)	
year = 2	0.0967 (0.0568)		0.1465 (0.0537)		0.1478 (0.0993)	
year = 3	0.0200 (0.0605)		0.1227 (0.0548)		0.1142 (0.0915)	
year = 4	0.0018 (0.0642)		0.0667 (0.0744)			
year = 5	0.0695 (0.0607)		-0.2395 (0.1893)			
year = 6	0.0843 (0.0674)		-0.2568 (0.1723)			
year = 7	0.1164 (0.0671)		-0.0735 (0.1711)			
year = 8	0.2204 (0.0958)					
<i>Fixed-effects</i>						
id_name	Yes		Yes		Yes	
year	Yes		Yes		Yes	
<i>Fit statistics</i>						
Observations	5,882		5,882		5,843	
R ²	0.73786		0.73699		0.73070	
<i>Results by buffer</i>						
Buffer 1000 m - 3500 m	Graph	!	Graph	!	Graph	!
Nature of school	Graph	!	Graph	!	Graph	!
<i>Clustered (id_name) standard-errors in parentheses</i>						
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>						

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- **Results in reading literacy**
- Results in university participation

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Results in reading literacy test.

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Heterogeneities in reading literacy score of students by nature of the school

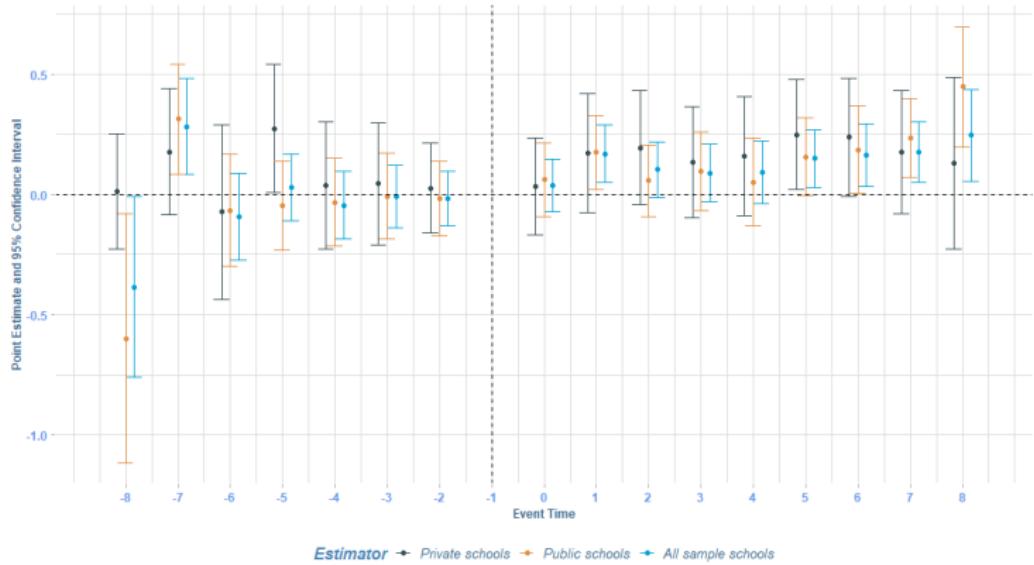


Figure: 10 % advance of construction

Reading literacy score for all the different stages of construction.

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

Results by buffer

Buffer 1000 m - 3500 m



Nature of school



Clustered (id_name) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

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Results in university participation

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	
<i>Variables</i>		
year = -3	0.0016 (0.0499)	-0.1275 (0.1112)
year = -2	0.0525 (0.0521)	0.0038 (0.1437)
year = 0	0.0946 (0.0523)	-0.2892 (0.1876)
year = 1	0.1415 (0.0534)	0.1260 (0.1359)
year = 2	0.1342 (0.0633)	
<i>Fixed-effects</i>		
id_name	Yes	Yes
year	Yes	Yes
<i>Fit statistics</i>		
Observations	3,101	3,101
R ²	0.67737	0.66500
Within R ²	0.00350	0.00206
<i>Clustered (id_name) standard-errors in parentheses</i>		
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>		

Conclusions

- I evidenced an increase in the score of the results of mathematics and language on the standardized test for schools near roads under a concession agreement.
- I evidenced that the effect of the construction of a road under a concession agreement on education mainly benefits schools less than one kilometer away. The effect on education disappears in schools that are more than 2.5 km away from the road.
- The effect of building a road under a concession agreement is greater in public schools than in private schools.
- The labor force participation of students in schools less than a kilometer away from the road under a concession agreement decreases.
- The fraction of students from treated schools who complete a university degree increases.

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Checking the mechanism - Labor Force

- i. Labor Force: ↓ Participation of students in labor force.

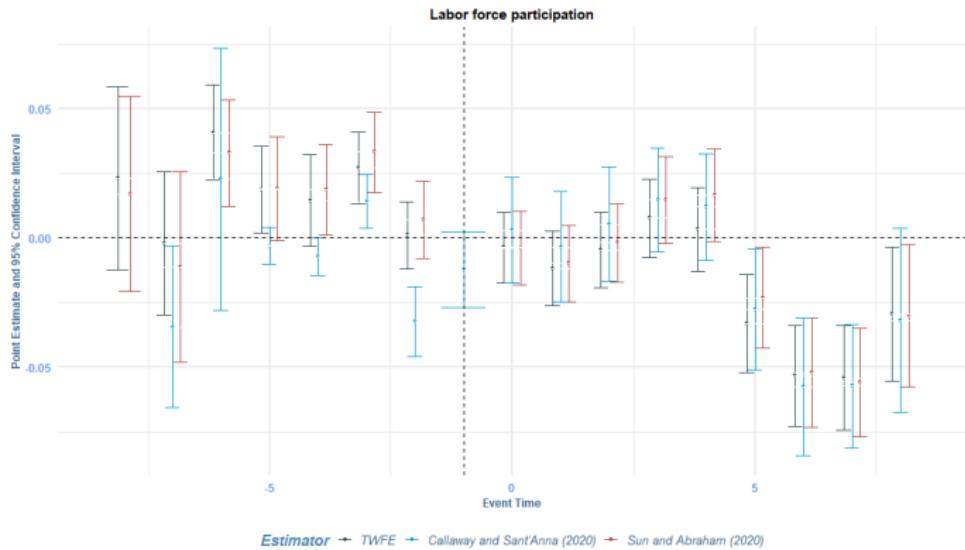


Figure: Impact on the fraction of students who participate in labor force

Checking the mechanism - Labor Force

i. Labor Force: ↓ Participation of students in labor force.

Dependent Variable:	Fraction of students who participate in labor force		
Model by level of construction :	10 %	graph!	50 %
<i>Variables</i>			
year = -8	0.3341 (0.1894)	0.0429 (0.0866)	0.1899 (0.0966)
year = -7	0.1566 (0.3387)	0.3807 (0.0985)	-0.0574 (0.0787)
year = -6	0.0765 (0.1561)	0.0685 (0.0815)	0.0028 (0.0843)
year = -5	-0.0458 (0.1150)	0.0578 (0.0788)	0.1307 (0.0986)
year = -4	0.0415 (0.0910)	0.0709 (0.0756)	0.0286 (0.0820)
year = -3	0.2354 (0.0819)	0.0228 (0.0653)	0.0773 (0.0846)
year = -2	0.0879 (0.0945)	-0.0199 (0.0528)	0.0933 (0.0941)
year = 0	-0.0100 (0.0670)	0.0872 (0.0661)	-0.0015 (0.0812)
year = 1	-0.0506(0.0687)	0.0482(0.0779)	-0.1120(0.0829)
year = 2	-0.0279(0.0790)	-0.1970(0.0759)	-0.0700(0.1469)
year = 3	-0.0699(0.0825)	-0.2323(0.0784)	0.0070(0.1439)
year = 4	0.0377 (0.0947)	0.0151 (0.1105)	
year = 5	-0.0143 (0.0922)	0.1681 (0.2386)	
year = 6	-0.3295(0.0876)	-0.3180(0.2464)	
year = 7	-0.2900(0.0868)	0.1621(0.2181)	
year = 8	-0.2143(0.1088)		
<i>Fixed-effects</i>			
id_name	Yes	Yes	Yes
year	Yes	Yes	Yes
<i>Fit statistics</i>			
Observations	5,882	5,882	5,843
R ²	0.47454	0.47006	0.46806
<i>Results by buffer</i>			
Buffer 1000 m - 3500 m	Graph !	Graph !	Graph !
Nature of school	Graph !	Graph !	Graph !

Clustered (id_name) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1



Checking the mechanism

ii. Teacher training: ↑ Proportion of teachers with university education.

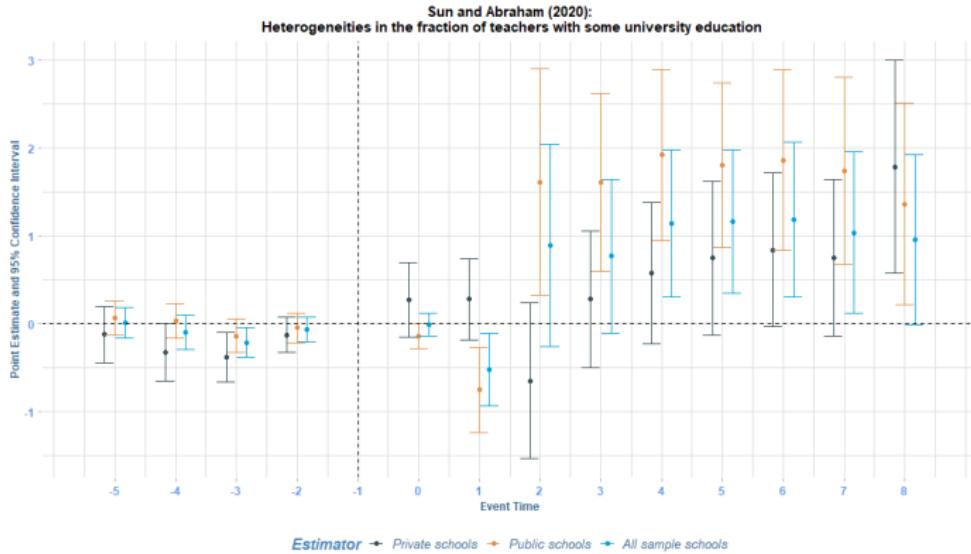
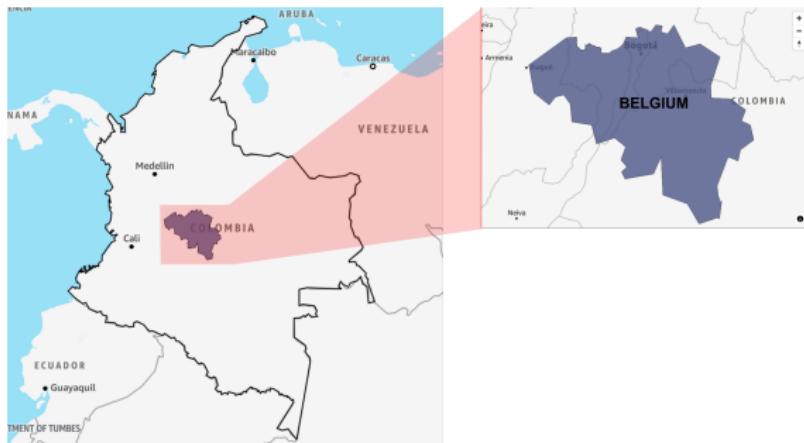


Figure: Number of teachers with at least a bachelor's degree title

Checking the mechanism

- iii. Family income: ✗ ✗ Family income of the student.

Context - Size



Key Takeaways

- Colombia has a lower GDP and GDP per capita compared to Belgium.
- Belgium has a more developed road network and better road quality.
- Colombia has a lower investment in Education than Belgium.

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Road concession system

The state entity assumes the character of the assignor and grants to an individual who holds the status of concessionaire, the operation, exploitation, management, total or partial, of a public service.



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What do we already know?

- Adukia et al., 2020 Children **stay in school longer and perform better on standardized tests** as an effect of 115,000 new roads.
- Donaldson, 2018 Railroads infrastructure **decreased trade costs and interregional price gaps, increased interregional and international trade and increased real income levels.**
- Fernández et al., 2020 shows how transportation infrastructure **promoted long-term employment opportunities and broke the labor bond between parents and children.**
- Fernald, 1999 Changes in roads has an **effect over the productivity** are mainly reflected in the intensive automotive production.
- Quintero and Sinisterra, WP2022 (**Colombia 1993-2012**) Measures road improvement and construction as a function of production and inequality.

- 1780 secondary schools were located with API and made up the sample.
- **987 schools** were implicated within a radius of 1000 meters from the road.
 - ▶ 250 Private schools and 737 Public.
- **12.9%** and **10.4%** were **the percentage of students who participated in labor force** in private and public schools, respectively.
- **Public Schools** can not select their teachers due to the fact that teachers obtain their positions through merit contests.
- **Private Schools** can select their teachers and teachers can select the school where they want to work.
 - ▶ By seeing improvements in the infrastructure a teacher with better qualities could select a school and this could impact in the school achievements.

Table: 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	sd	mean	sd
Students with university studies *	0.148	0.192	0.127	0.165
Students in labor force +	0.101	0.162	0.142	0.197
Reading literacy Score	0.491	0.057	0.484	0.051
Mathematics score	0.433	0.082	0.425	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

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

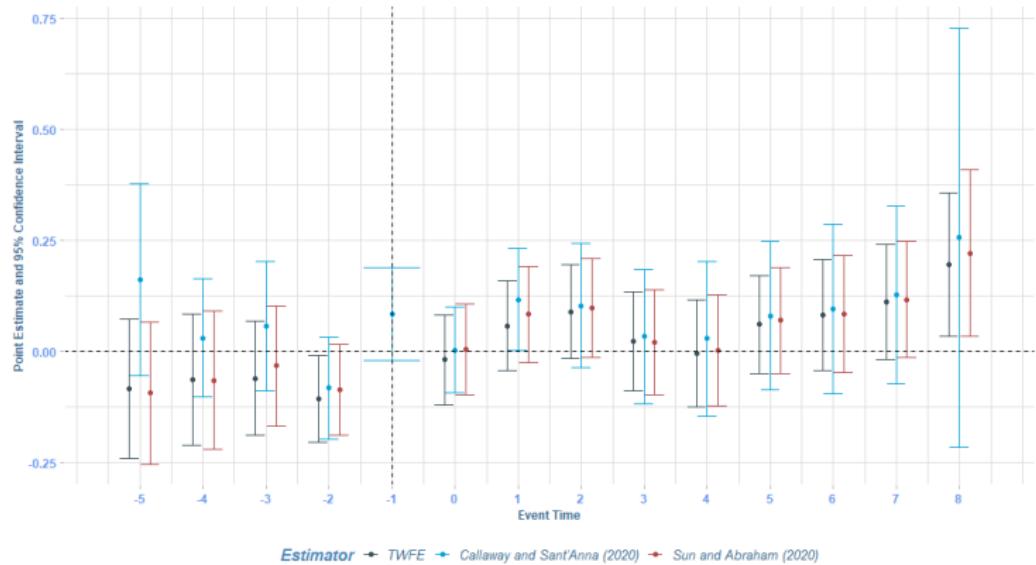


Figure: 10 % advance of construction

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

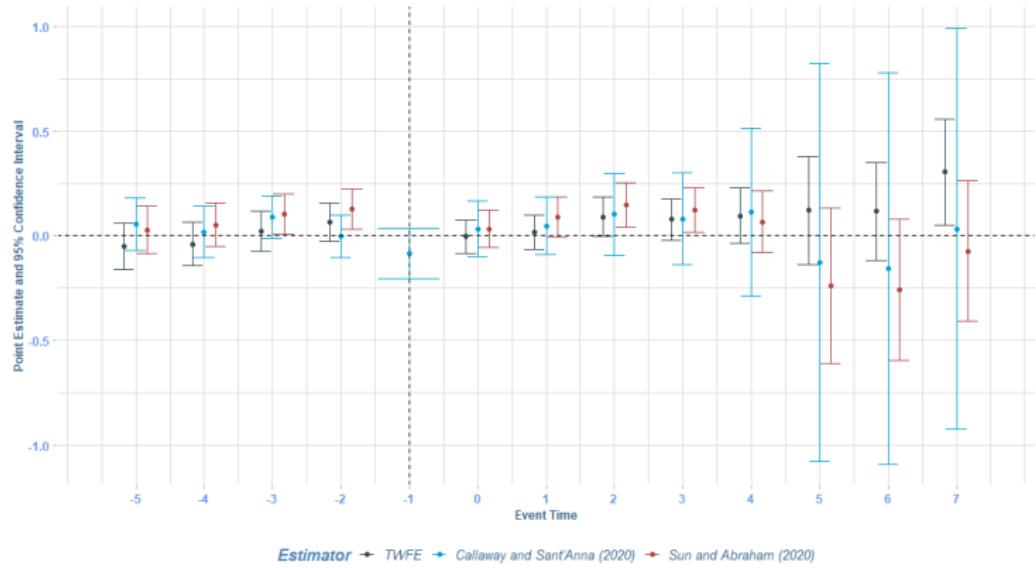


Figure: 50 % advance of construction

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

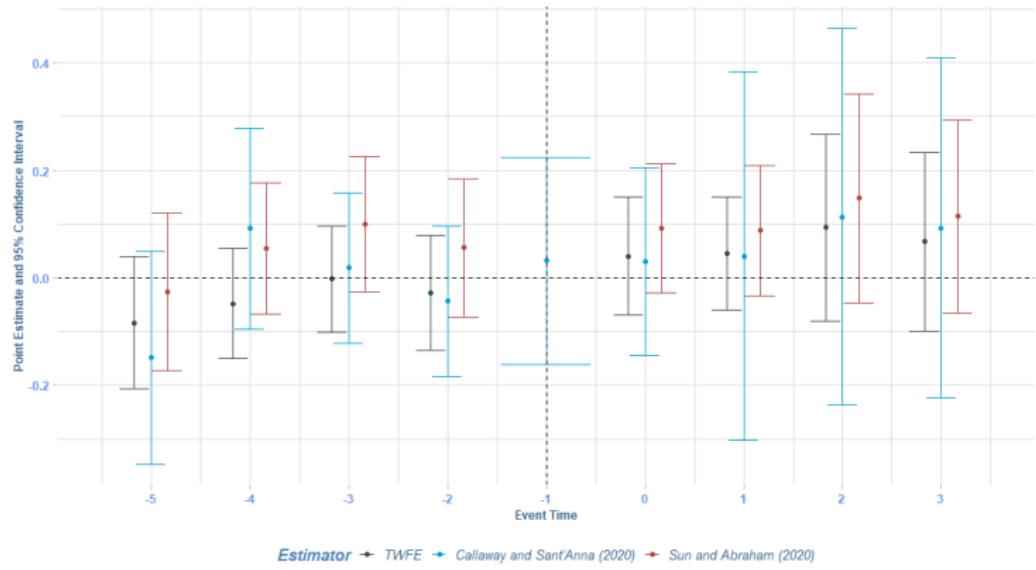


Figure: 100 % advance of construction

Results in math test. [Back!](#)

Impact of road construction on math score by distance of school from road in Math Result

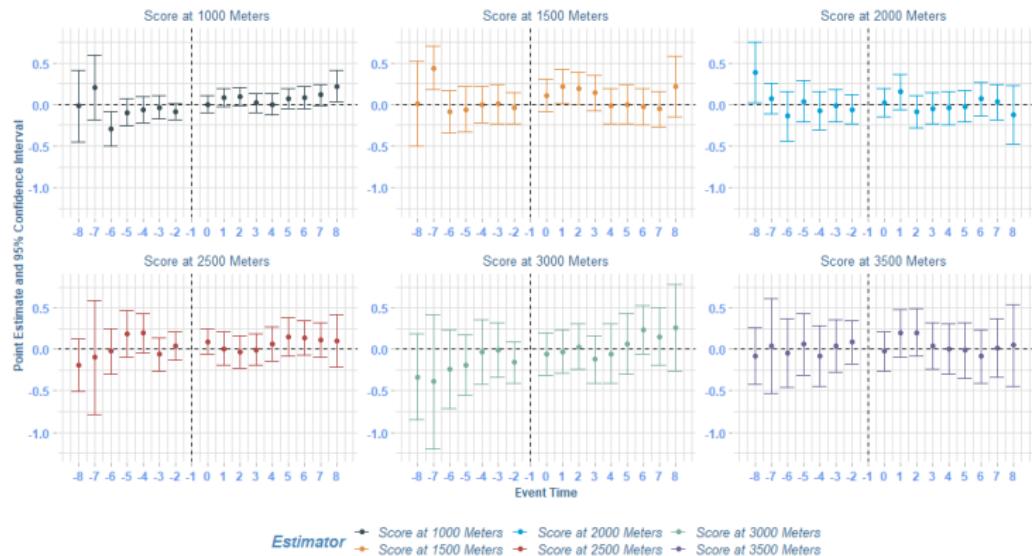


Figure: 10 % advance of construction

Results in math test.

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Impact of road construction on math score by distance of school from road in Math Result

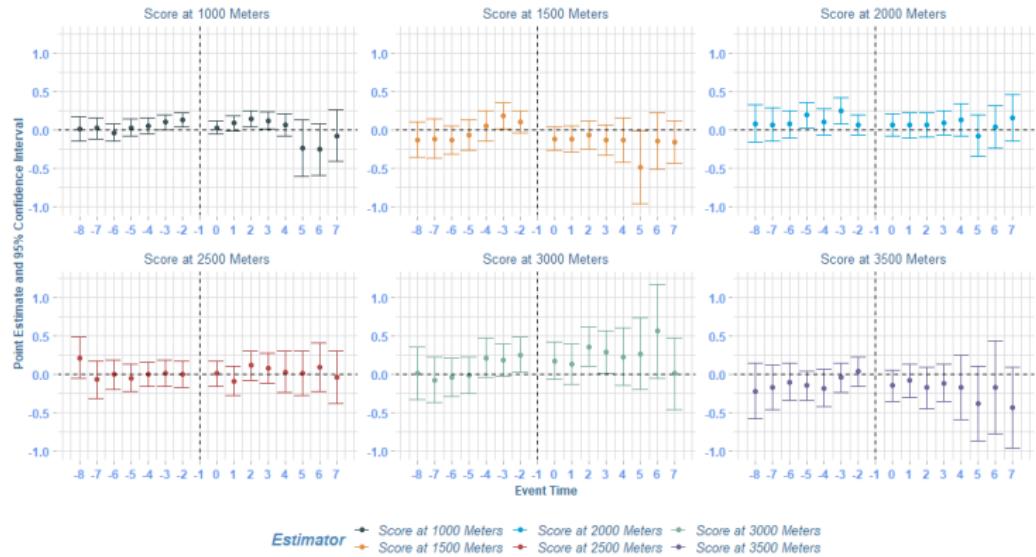


Figure: 50 % advance of construction

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Impact of road construction on math score by distance of school from road in Math Result

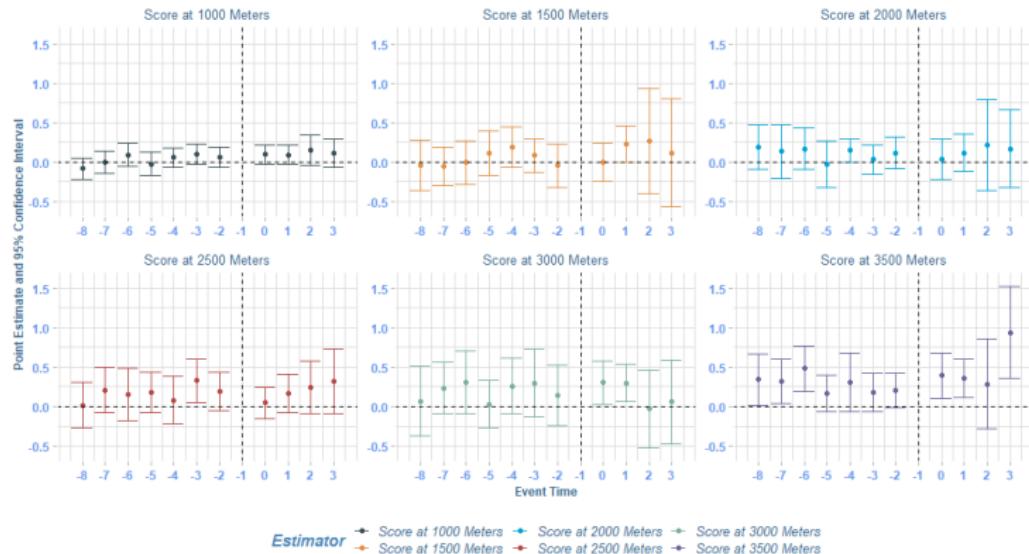


Figure: 100 % advance of construction

Results in math test.

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Estimation of heterogeneities (Sun and Abraham, 2021 estimator) in mathematics results according to the nature of the school

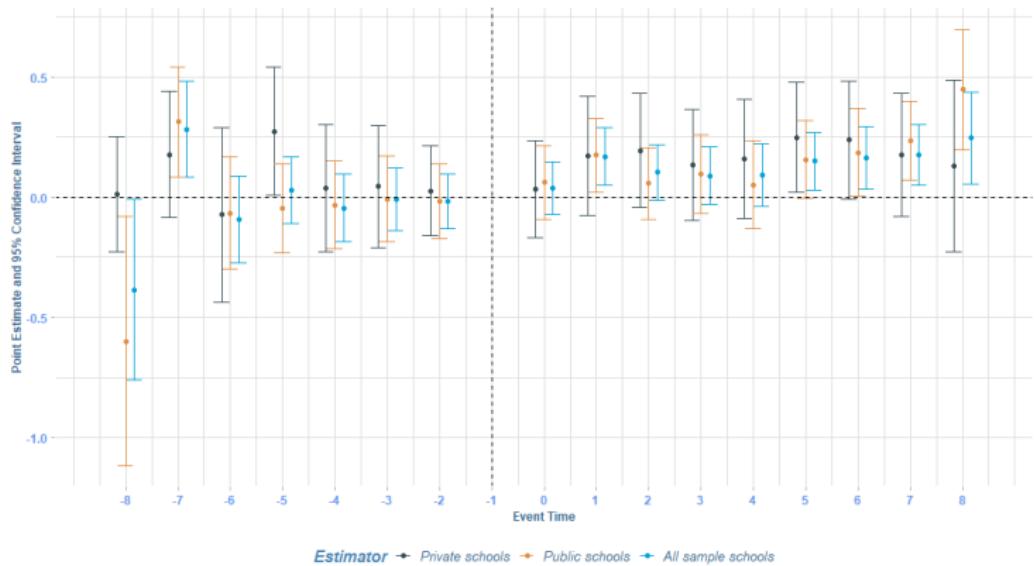


Figure: 10 % advance of construction

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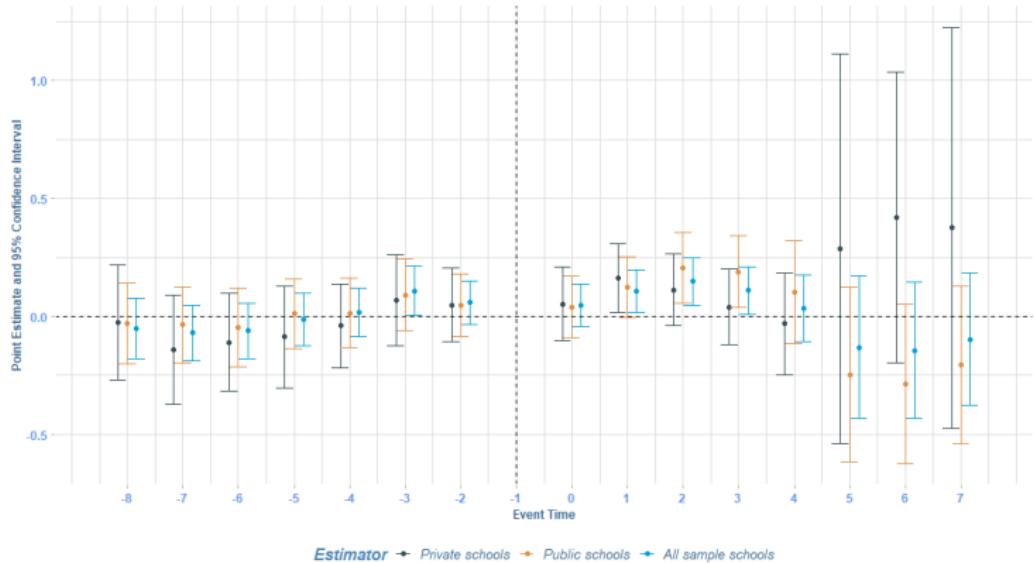


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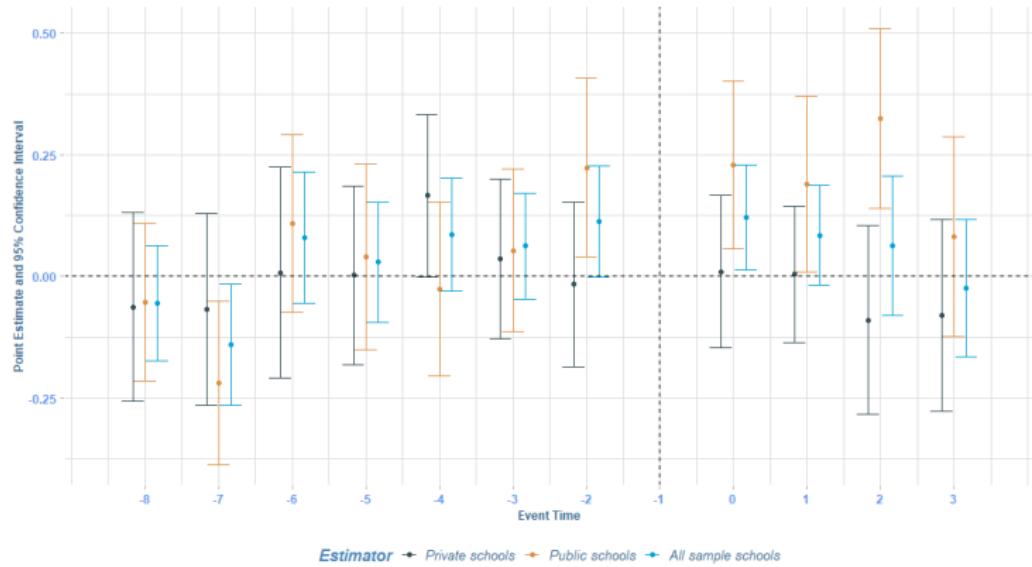


Figure: 100 % advance of construction

Results in reading literacy test.

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

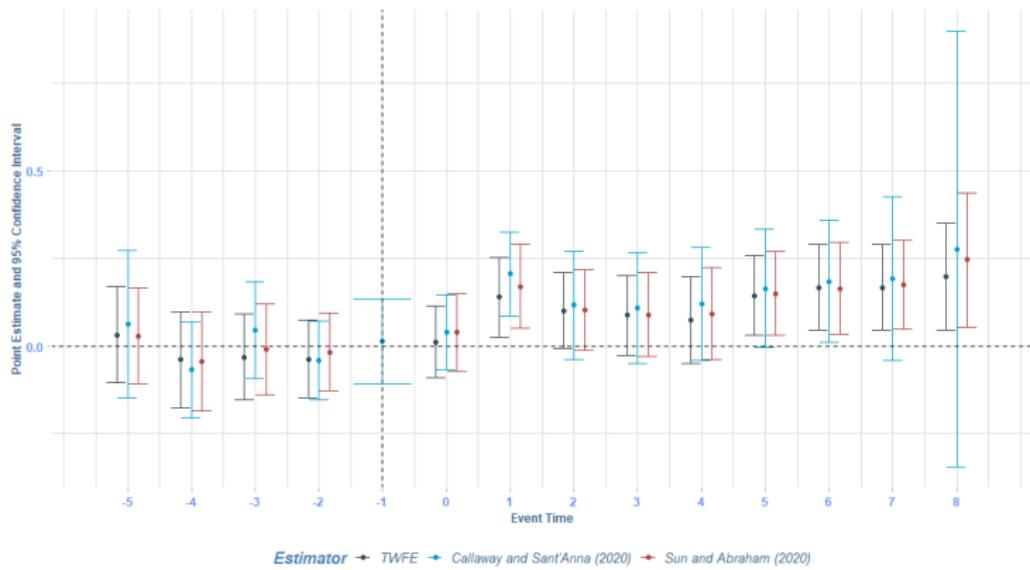


Figure: 10 % advance of construction

Results in reading literacy test.

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

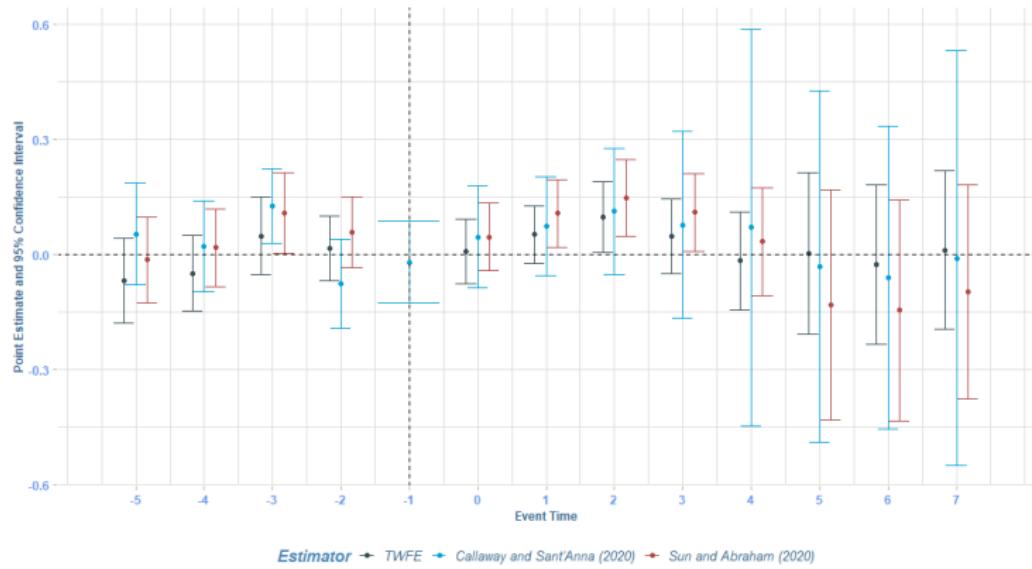


Figure: 50 % advance of construction

Results in reading literacy test.

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

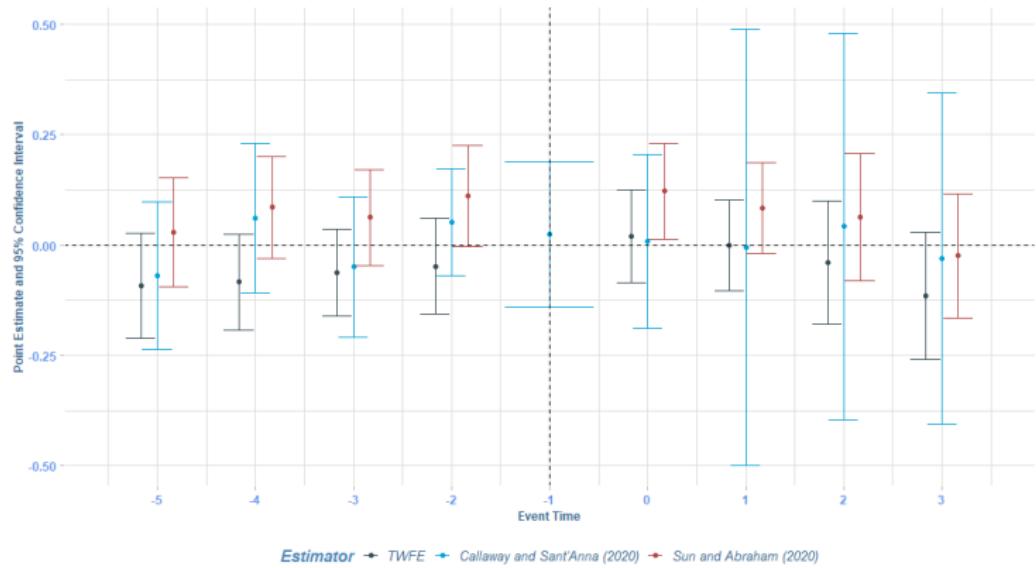


Figure: 100 % advance of construction

Results in reading literacy test.

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Impact of road construction on reading literacy score by distance of school from road

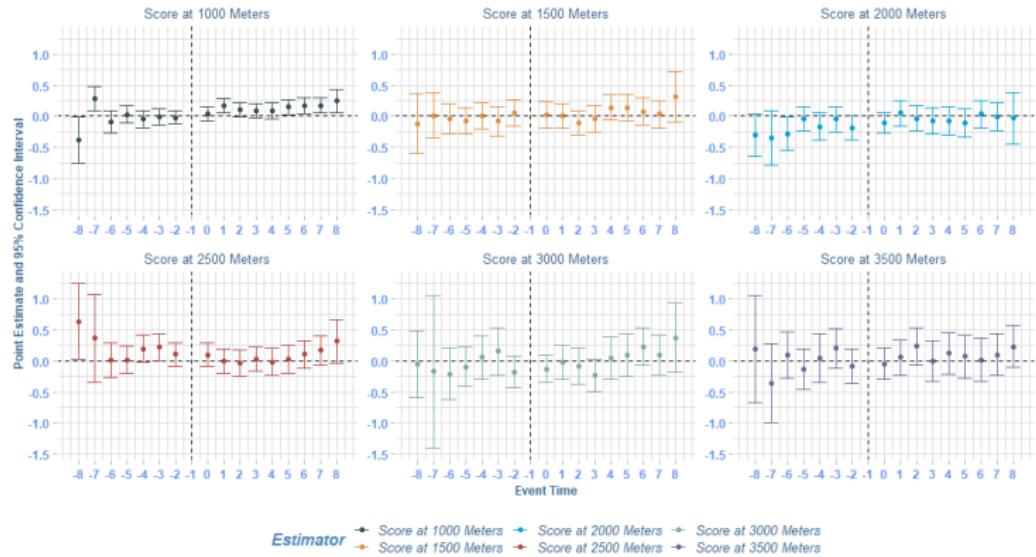


Figure: 10 % advance of construction

Results in reading literacy test.

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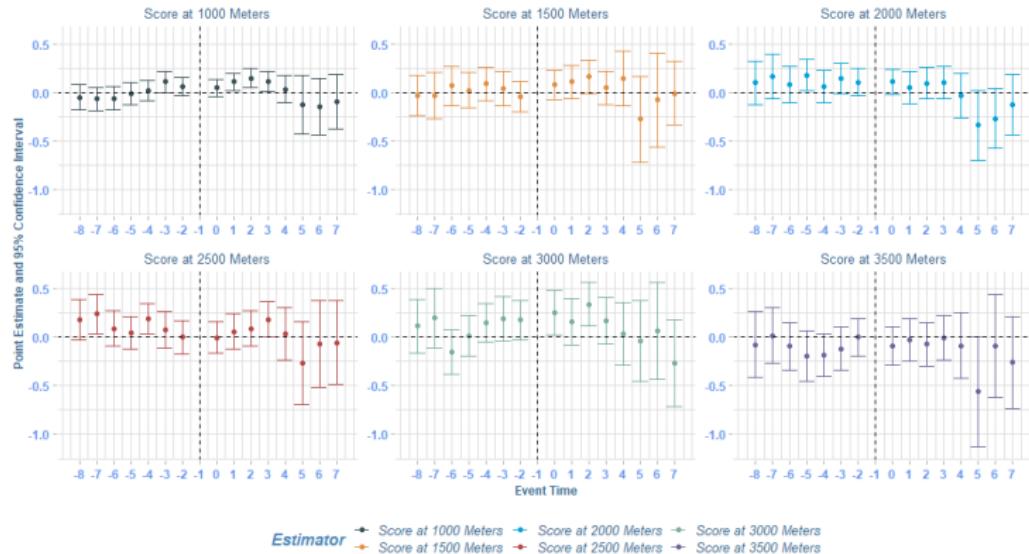


Figure: 50 % advance of construction

Results in reading literacy test.

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Impact of road construction on reading literacy score by distance of school from road

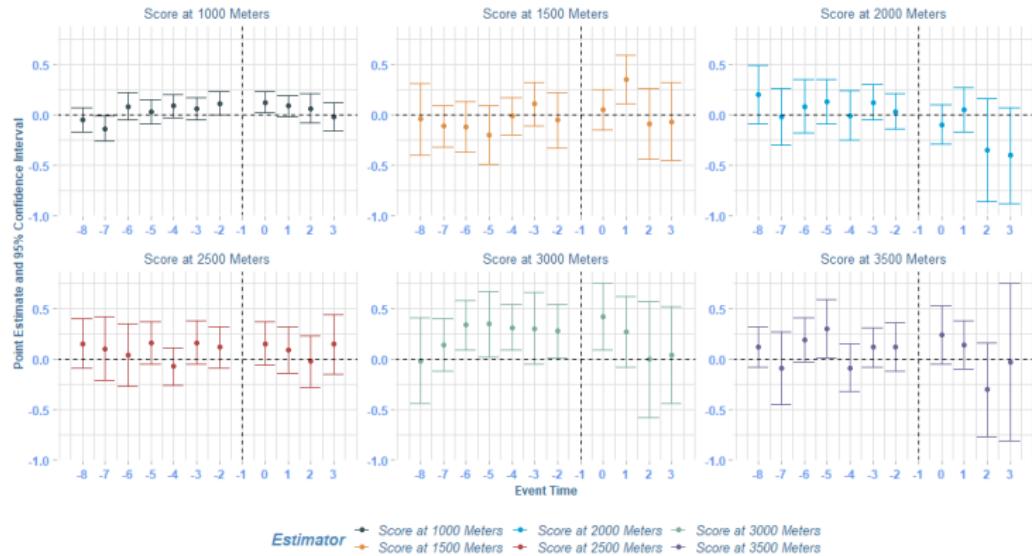


Figure: 100 % advance of construction

Results in reading literacy test.

Heterogeneities in reading literacy score of students by nature of the school

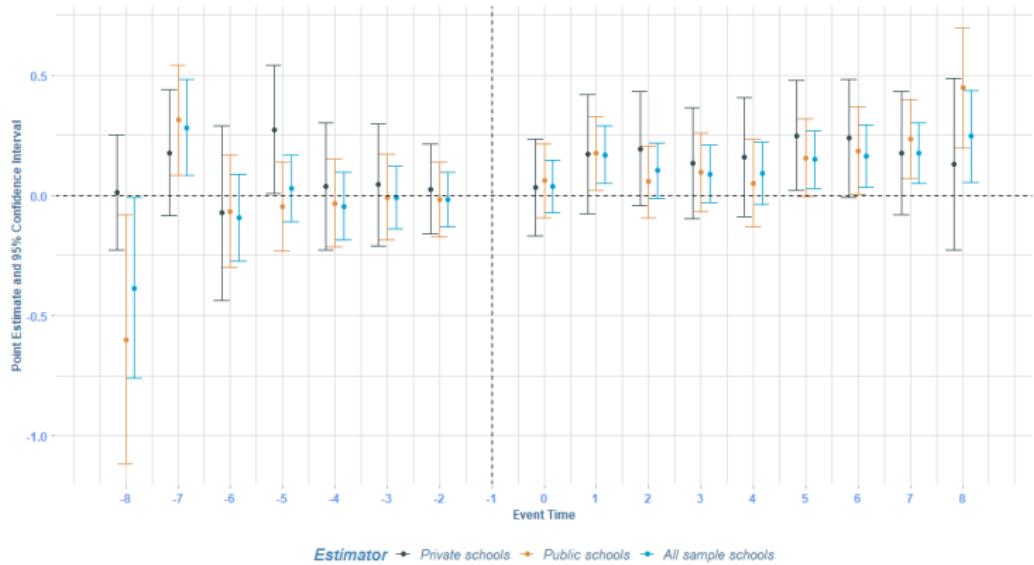


Figure: 10 % advance of construction

Results in reading literacy test.

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Heterogeneities in reading literacy score of students by nature of the school

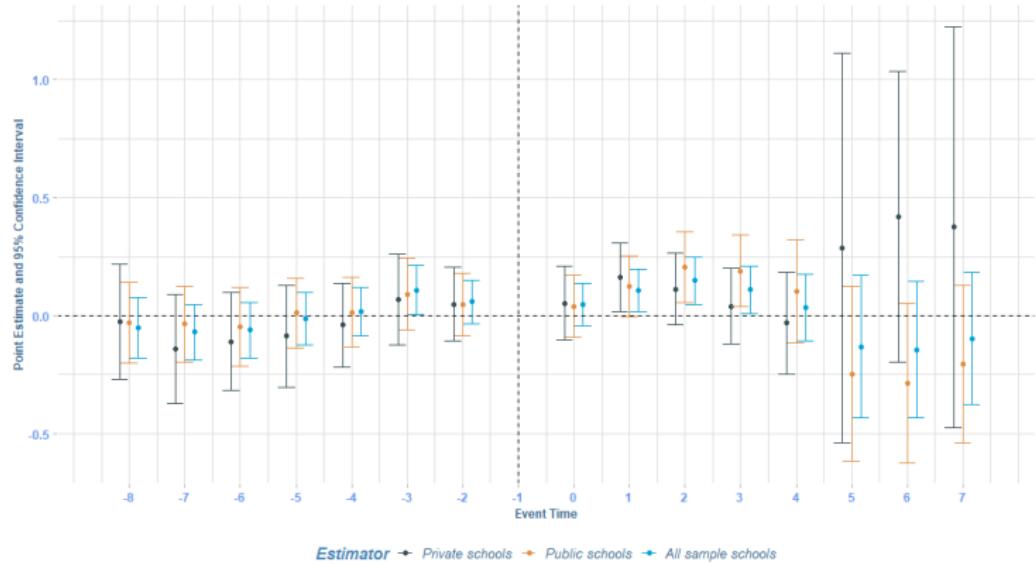


Figure: 50 % advance of construction

Heterogeneities in reading literacy score of students by nature of the school

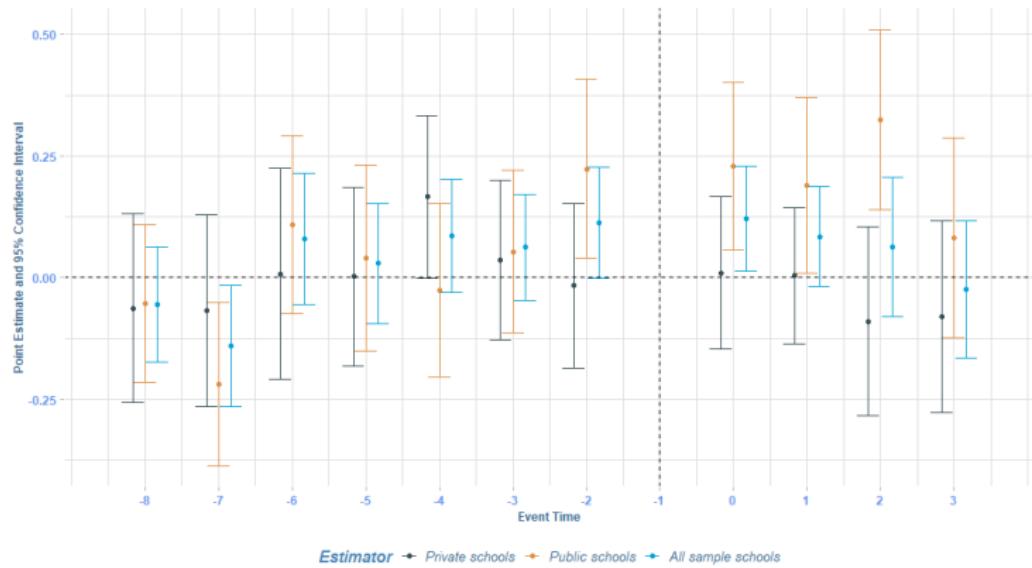


Figure: 100 % advance of construction

Results in labor force.

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Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

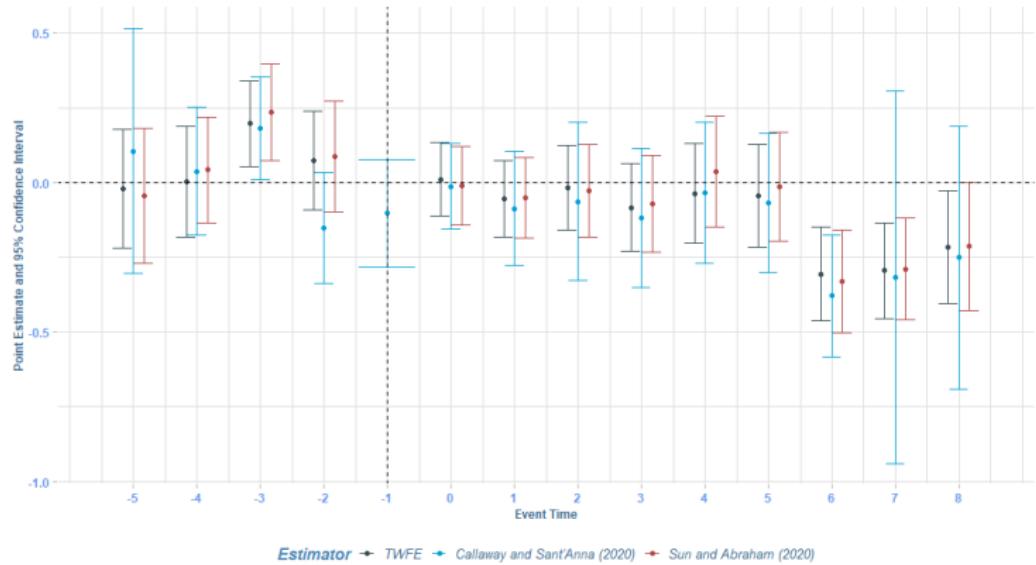


Figure: 10 % advance of construction

Results in labor force.

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Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

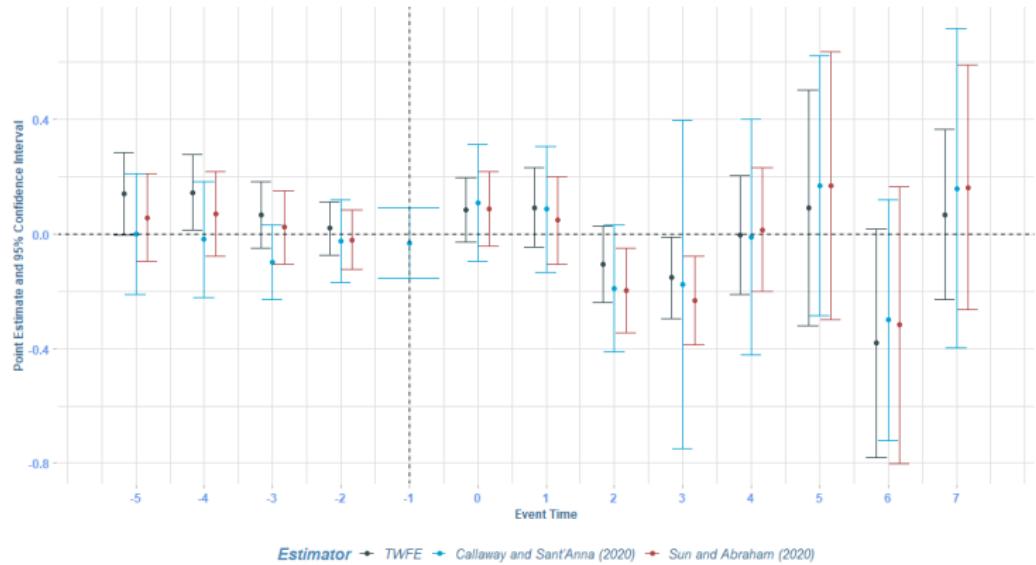


Figure: 50 % advance of construction

Results in labor force.

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Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

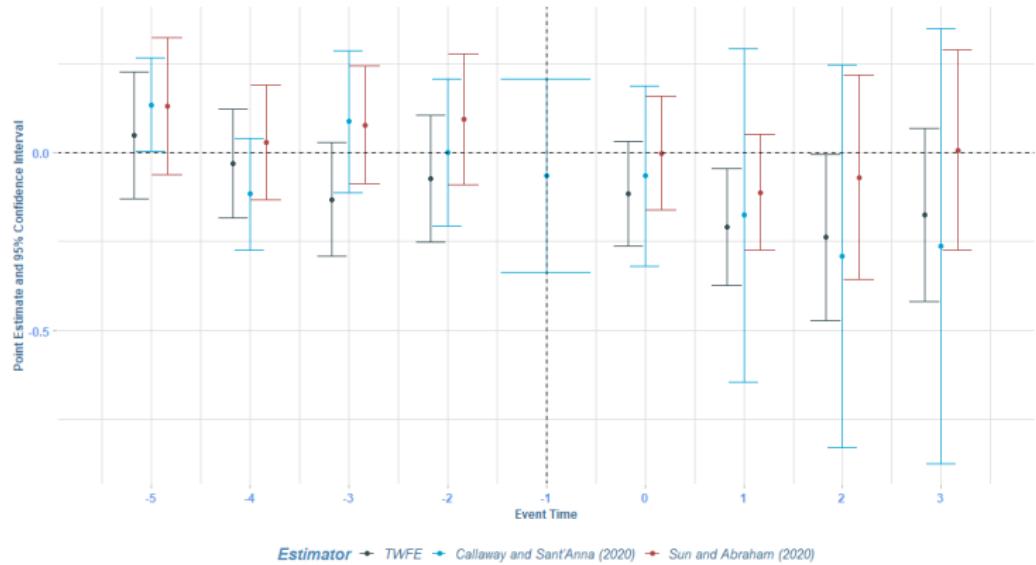


Figure: 100 % advance of construction

Results in labor force.

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Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

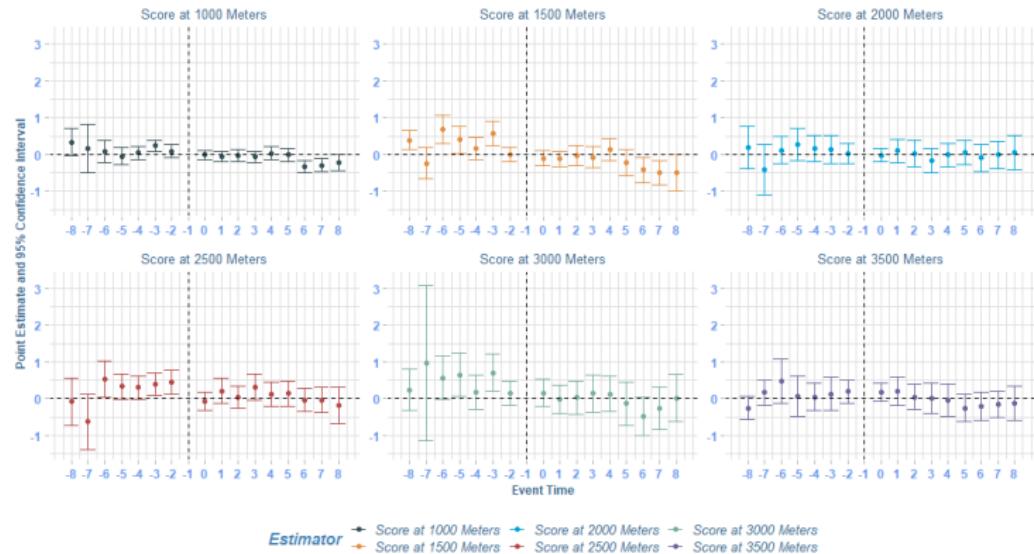


Figure: 10 % advance of construction

Results in labor force.

Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

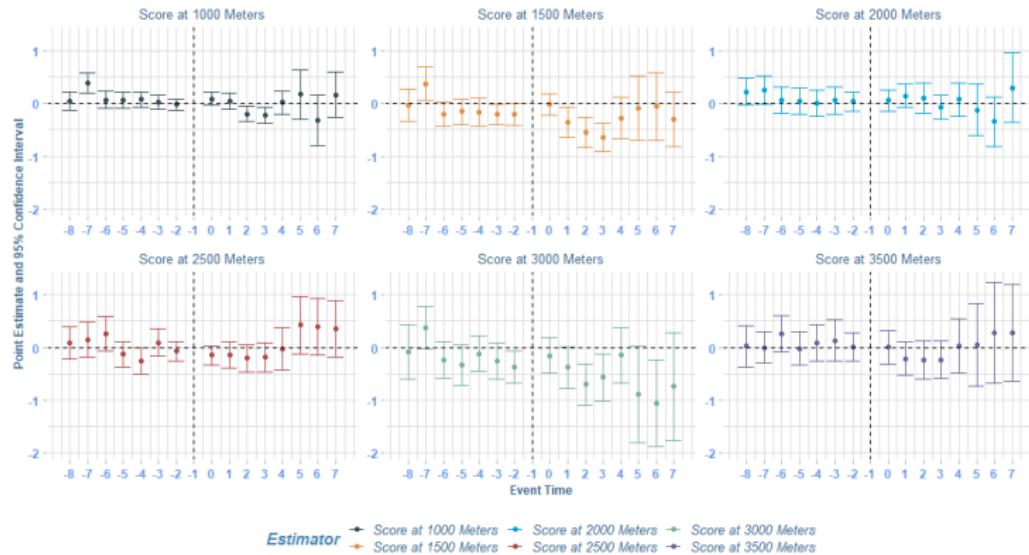


Figure: 50 % advance of construction

Results in labor force.

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Impact of Roads on average results on the fraction of students who participate in labor force in the last year of secondary education.

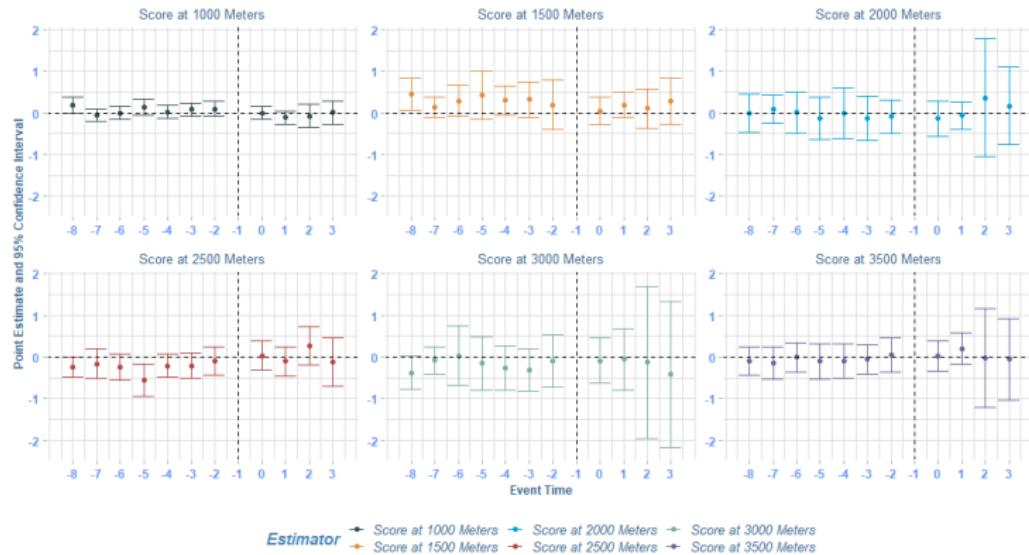


Figure: 100 % advance of construction

Results in labor force.

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Estimation of heterogeneities (Sun and Abraham, 2021 estimator) in labor force results according to the nature of the school.

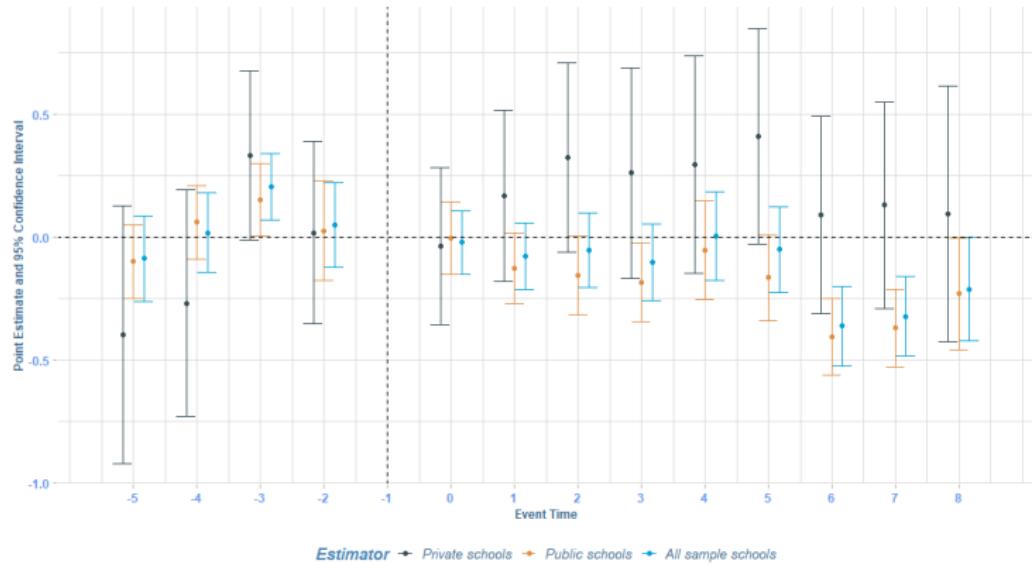


Figure: 10 % advance of construction

Results in labor force.

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Estimation of heterogeneities (Sun and Abraham, 2021 estimator) in labor force results according to the nature of the school.

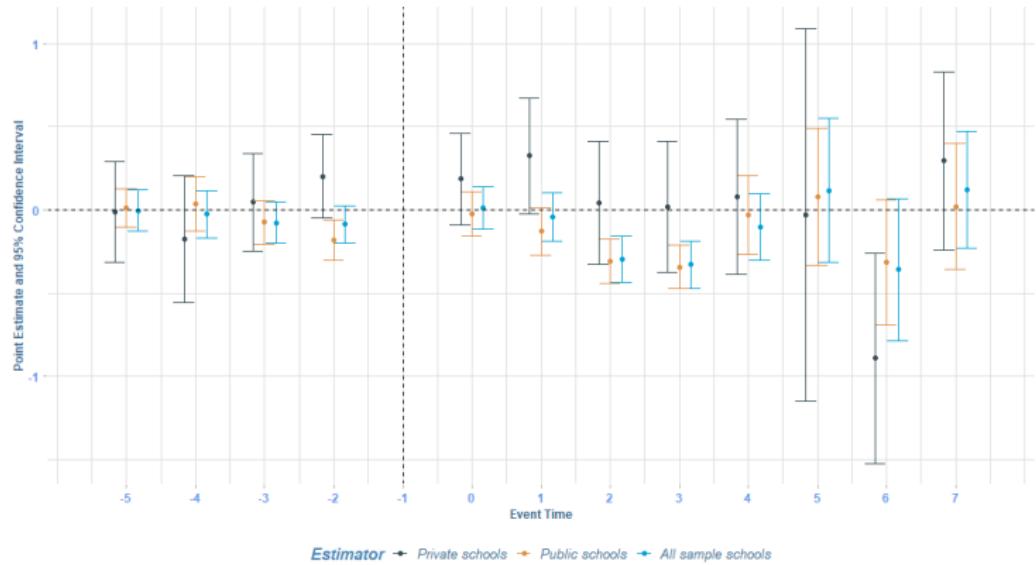


Figure: 50 % advance of construction