

Black Gold and Dull Minds? The Impact of Hydrocarbon Exploration Announcements on Education in Colombia

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- 2 Setting: hydrocarbon exploitation in Colombia and related literature
- 3 Empirical framework
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- 5 Results in elementary school
- 6 Results in secondary school
- 7 Falsification Tests and Robustness Check

Why This Study Matters

- The called “resource curse” is important for the aggregate economy (e.g. economic growth Brunschweiler, 2008; Frederick, 2011; Quintero Otero, 2020; Sala-i Martin & Subramanian, 2012)
- Such effects extend beyond the aggregate economic activity (Cockx and Francken, 2016). Recent evidence suggests that resource curse may also play a significant role in determining other outcomes such as conflict (Dube Vargas, 2013), infrastructure (Baynard, 2011; Sangare & Maisonnave, 2018), health (Brisbois et al., 2019; Nguyen, Do, Halkos, Wilson, 2020), and education (Farzanegan Thum, 2018; Zuo, Schieffer, Buck, 2019).
- There is not enough causal evidence in the literature of such effects in the educational market.
- We study how Colombia’s hydrocarbon policy affects school performance in primary and secondary education.

Why This Study Matters

- This paper aims to provide new evidence on the impact of hydrocarbon exploration on dropout rates.
- What is new here?
 - ▶ Dropout rates are a major policy concern globally and in Colombia.
 - ▶ There are more than 65,000 oil fields around the world, in Colombia 157 gas and oil fields. Colombia is the fourth (third) largest oil (gas) producer in South America.
 - ▶ The oil and gas industry accounts for about 3% of Colombia's GDP and employs about 100,000 people.
- What is the key trade-off to study here?
 - ▶ A fundamental aspect is that we explore the trade-off between changing expectations among children (and their families) in and out of working age.

Why This Study Matters for Colombia

- For developing countries such as Colombia, the effect on education has not yet been evidenced. But Since 2012:
 - ▶ 985 schools have been affected.
 - ▶ 120,260 students in elementary school have been affected¹.
 - ▶ 95,190 students in secondary school have been affected ².

¹2.46% of all students in elementary school

²2.28% of all students in secondary school

Questions we expect to answer.

Research Question 1.1

What is the impact of hydrocarbon exploration announcements on dropout rates (and academic performance) in Colombia?

Hypothesis 1: Households believe that Hydrocarbon exploration will increase future income, thus households change their behavior related to education by expectations.

$$HEA^3 \Rightarrow \uparrow \underbrace{E[w_h]}_{\text{expected family income}} \Rightarrow \underbrace{\Delta F, \Delta S_t}_{\text{Family's and Student's attributes}} \Rightarrow \underbrace{\Delta s}_{\text{Student's studying time}}$$

³Where HEA is the Hydrocarbon Exploration Announcements

Questions we expect to answer.

Research Question 1.2

Is there a trade-off in decision-making among children (and their families) in and out of working age?

Hypothesis 2: Children in working age may increase their income expectations, while children out of working age do not.

What will we find in this presentation?

The following effects result from changes in future income expectations by Oil Exploration Announcements:

- Dropout rate for students in elementary school decreases
- Dropout rate for students in secondary school increases
- Dropout rate in elementary decreases significantly more in males than in females

Exploration and Production (E&P) Contract in Colombia

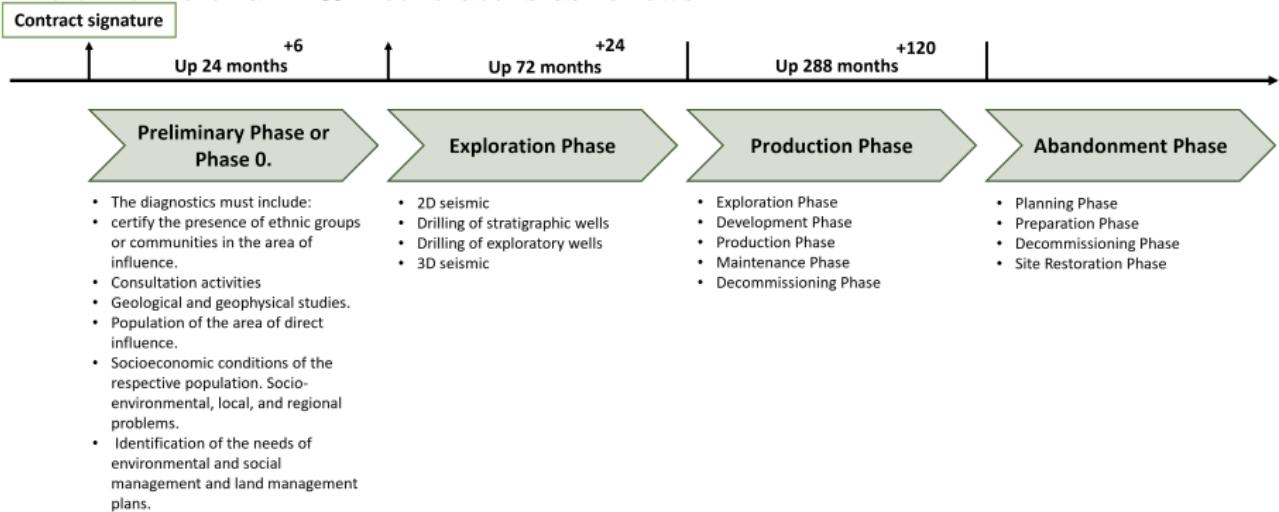
- Overview of the Colombian oil and gas industry and the importance of E&P contracts for investment and development.
- Contract Details: Key terms and conditions of the E&P contract, including:
 - ▶ Area of exploration and production
 - ▶ Duration of the contract
 - ▶ Company's obligations (seismic studies, drilling, environmental impact assessments)
 - ▶ Royalties and taxes to be paid to the Colombian government
 - ▶ Dispute resolution procedures

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The context of hydrocarbon exploitation in Colombia.

The timeline of an E&P contract is as follows:

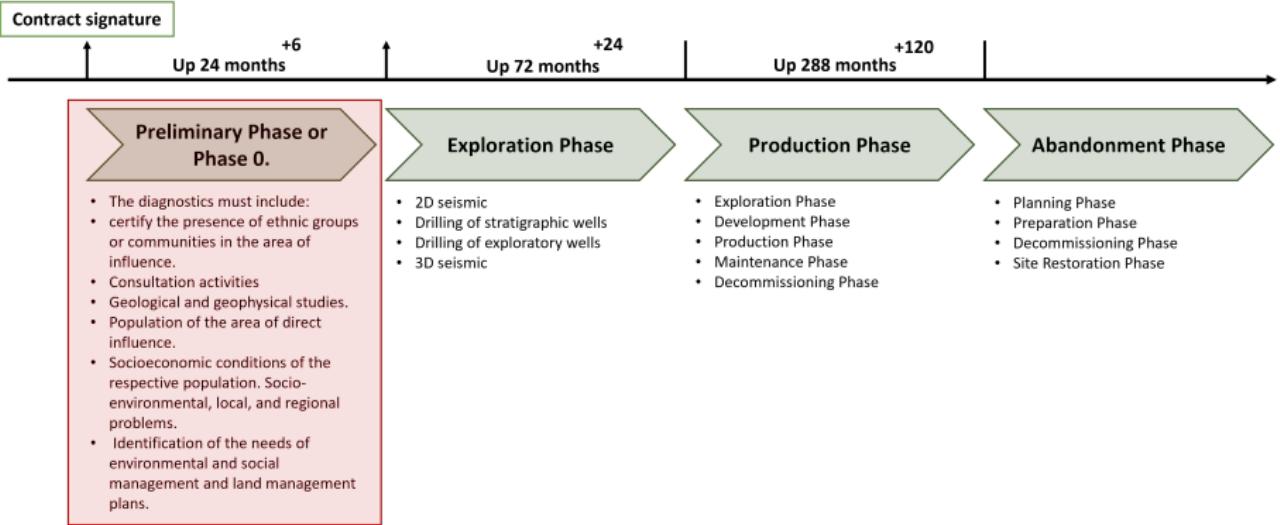


Key Points:

- The auction is conducted with incomplete and imperfect information. Nothing assures the bidder that he will find oil or gas.
- The existence of oil under the earth is exogenous to the educational level.

The context of hydrocarbon exploitation in Colombia.

Why is special this phase?:



- This phase does not include contractual investments.
- All signed contracts complete the phase 0.
- The communities are informed of the details of exploration in the prior consultation.
- Prior consultations allow the community to be informed about future investments

Related Literature

In this section, we review the literature on various topics related to the impact of different factors on behavior and Education.

- Income expectations and behavior: households adjust their consumption plans based on their income forecasts, and often underestimate their future incomes.⁴ . [see more!](#)
- Income expectations and schooling: Income expectations may play a role in the decision to attend college, but the findings are mixed and may be influenced by gender and cultural factors.⁵ [see more!](#)
- Income changes: A \$1,000 increase in annual income raises young children's achievement by 5%-6% of a standard deviation⁶. [see more!](#)
- Oil exploration and production: Intensive drilling activities have been found to decrease enrollment, Offshore oil and gas production can have mixed impacts on social institutions, which may impact academic performance. ⁷. [see more!](#)
- External infrastructure interventions: School facilities, libraries, and new schools can improve learning, enrollment, and student outcomes ⁸. [see more!](#)

⁴ Authors: Das 1997, Roth 2017, and Roth 2018

⁵ Authors: Rouse 2004, Bosworth 1985, Beffy 2012, Smith 1990

⁶ Authors: Duncan 2011, Dahl 2008

⁷ Authors: Zuo 2019, Laska 1993

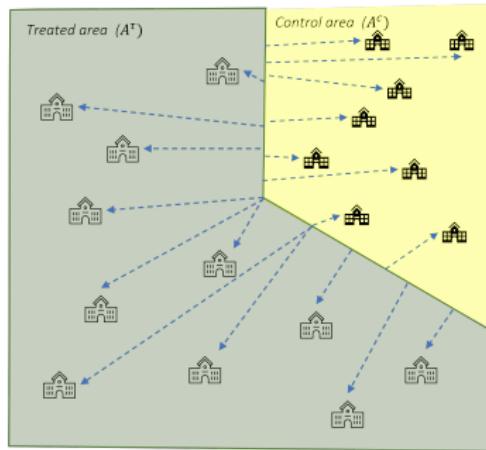
⁸ Authors: Barrett 2018, Fisher 2001, Cuesta 2016, and Belmonte 2020

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Geographic Regression Discontinuity (GRD) Design

E&P Contract A in t+9y



$$Y_i = \alpha + \beta_1 \cdot X_i + \beta_2 \cdot Di + \varepsilon_i$$

where:

- Y_i is the outcome variable for school i
- X_i is the running variable (Distance of the school i to threshold)
- $D = 1$ if the school $i \in A^t$

GRD Design: Intention-to-treat (ITT)

- Here we estimate an ITT in the sense that our **local** randomized study all students (and families) who are randomized (geographically) are included in the statistical analysis and analyzed according to the group they were originally assigned, regardless of what treatment (if any) they received.
- Between 2002 and 2012, 40 percent of the cases the Hydrocarbon Exploration passed to the production phase.
- The first stage in this case is not easy. Expectations may change in different ways.
- If the E&P Contract intervention is truly effective, an ITT analysis will provide an unbiased estimate of the efficacy of the intervention at the level of adherence in this setting.

Empirical framework

The existence of oil under the earth is exogenous to the educational level. Finding oil is a random treatment to those who live above the new oilfield.

Analysis 3.1 Assumption 1.

Conditional Local Geographic Treatment Ignorability (Keele and Titiunik 2016):

$$Y_{i1}, Y_{i0} \perp\!\!\!\perp T_i | d_i < D$$

The potential outcomes of individual i are independent of treatment T_i conditional on being in close neighborhood to the border, with d_i being the (shortest) distance to the border and D a specified maximum distance to the border

Empirical framework

The exploration areas auctioned in an E&P contract are created based on mining geological conditions at depths of more than three thousand feet. This implies that these areas do not overlap with other administrative geographies.

Analysis 3.2 Assumption 2.

Compound Treatment Irrelevance Assumption (Keele and Titiunik 2016):

Let G be the set of all administrative geographies. Then, the statement can be written mathematically as follows:

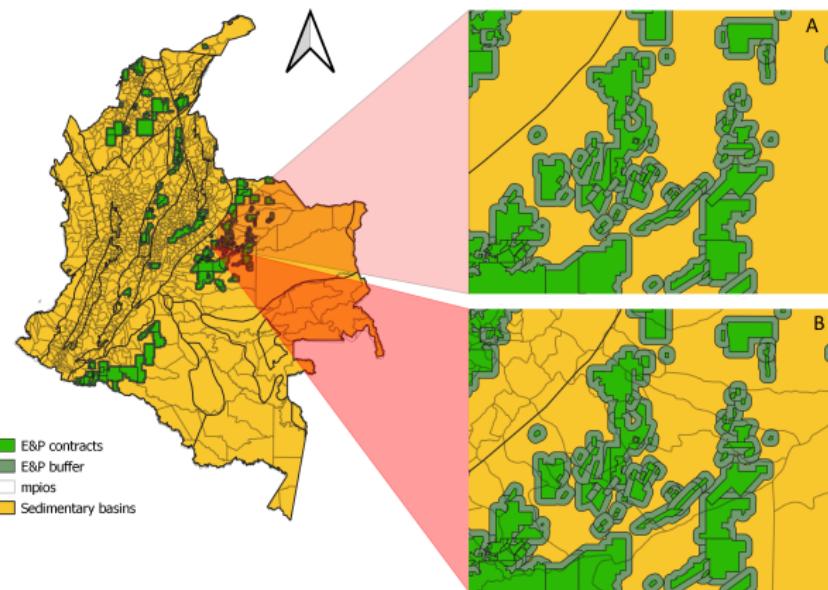
$$\#B \subseteq AT, \forall G \in G \setminus \{AT\} : B \subseteq G.$$

The border between B and AT is unique and does not overlap with any other area.

Empirical framework

Analysis 3.3 Assumption 2.

Compound Treatment Irrelevance Assumption (Keele and Titiunik 2016):



Empirical framework

Analysis 3.4 Assumption 3.

Naive distance (Keele and Titiunik 2016):

Assume that the $Pr(T_i = 1) = 1$ for all i such that coordinates $s_i \in A^T$ and when $Pr(T_i = 0) = 1$ for all i such that coordinates $s_i \in A^c$ then we assume a discontinuity is sharp. Then:

$$\tau(b) = E [Y_{i1} - Y_{i0}] \therefore$$

$$\tau(b) \forall b \in \beta \Rightarrow$$

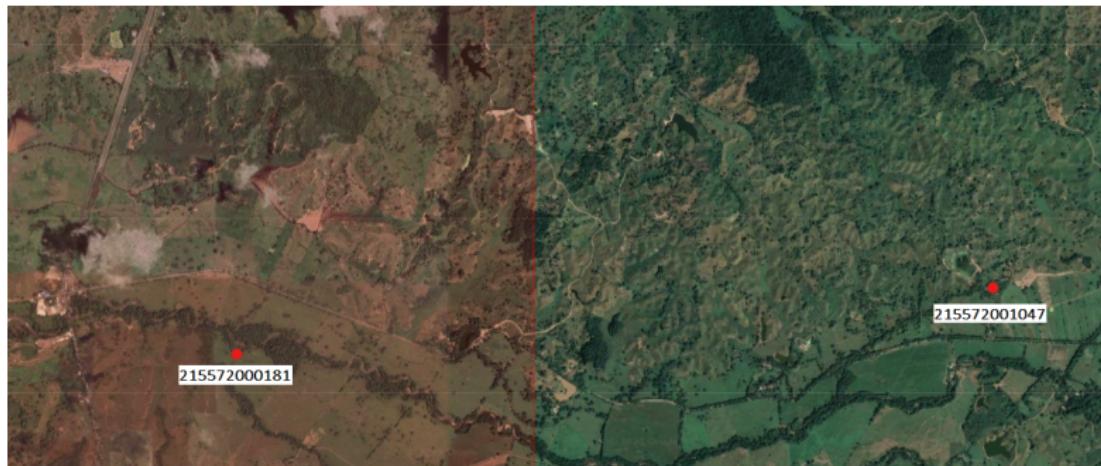
$$\tau(b^n) = \tau(b^q) \forall b^n \in \beta, b^q \in \beta$$

Perpendicular Euclidean distance to the boundary does not mask important heterogeneities.

Empirical framework

Analysis 3.5 Assumption 3.

Naive distance (Keele and Titiunik 2016):



Perpendicular Euclidean distance to the boundary does not mask important heterogeneities.

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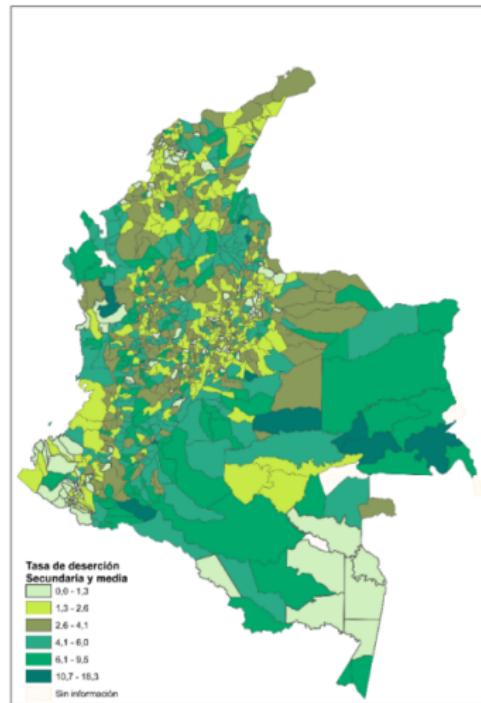
Data

The data used for the develop of this research are:

- SIMAT from 2012 - 2020
- E&P contracts in Colombia from 2012-2020 (ANH)
- Georeferenced base of school location (DANE)

Data

Dropout rate, Data Ministry of Education, 2018. Map prepared by LEE.



Data

Statistical significance from: $Variable_i = \alpha_i + \beta \cdot Treat_i \varepsilon_i$

Table: Descriptive statistics of the control and treatment group

| Variable | Treated Mean | Control Mean | Difference | $Pr(> t)$ |
|-----------------------------------|-----------------|-----------------|-----------------|-------------|
| Outcomes in Post-treatment Period | | | | |
| Dropout Rate | 0.17 (0.26) | 0.2 (0.28) | -0.028 (-0.014) | 0 |
| Dropout _{T2} | 0.3 (0.34) | 0.32 (0.34) | -0.024 (0.001) | 0.003 |
| N Treated | | | | 4636 |
| N Control | | | | 3097 |

Data

Statistical significance from: $Variable_i = \alpha_i + \beta \cdot Treatment_i \varepsilon_i$

Table: Descriptive statistics of the control and treatment group

| Variable | Treated Mean | Control Mean | Difference | $Pr(> t)$ |
|----------------------------------|-----------------|-----------------|-----------------|-------------|
| Covariates | | | | |
| Age | 13.31 (24.4) | 13.56 (29.87) | -0.245 (-5.47) | 0.693 |
| Medium Economic Level | 0.04 (0.13) | 0.02 (0.08) | 0.022 (0.047) | 0.62 |
| Low Economic Level | 0.86 (0.24) | 0.9 (0.2) | -0.04 (0.042) | 0.44 |
| Frac. Subsidized | 0.53 (0.2) | 0.53 (0.21) | -0.005 (-0.01) | 0.259 |
| Frac. Repeaters | 0.53 (0.2) | 0.53 (0.21) | -0.005 (-0.01) | 0.259 |
| Frac. New Students | 0.53 (0.2) | 0.53 (0.21) | -0.005 (-0.01) | 0.259 |
| Frac. Male | 0.53 (0.2) | 0.53 (0.21) | -0.005 (-0.011) | 0.26 |
| Frac. Female | 0.47 (0.2) | 0.47 (0.21) | 0.005 (-0.011) | 0.26 |
| Robustness Post-treatment Period | | | | |
| Emigrated Out | 0.23 (0.28) | 0.23 (0.29) | -0.006 (-0.012) | 0.332 |
| Immigrated | 0.001 (0) | 0.001 (0) | 0.001 (0) | 0.118 |
| Emigrated | 0.001 () | 0.001 (0) | 0.001 (0) | 0.108 |
| N Treated | | | 4636 | |
| N Control | | | 3097 | |

Contents

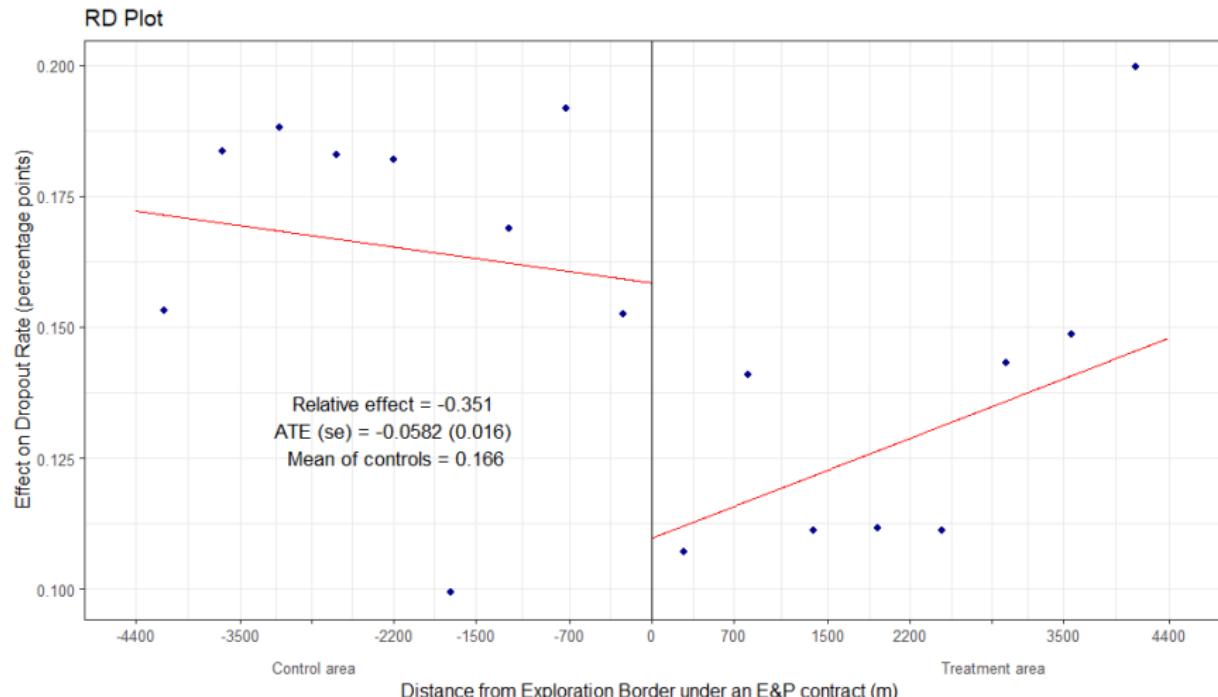
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General estimates in elementary school

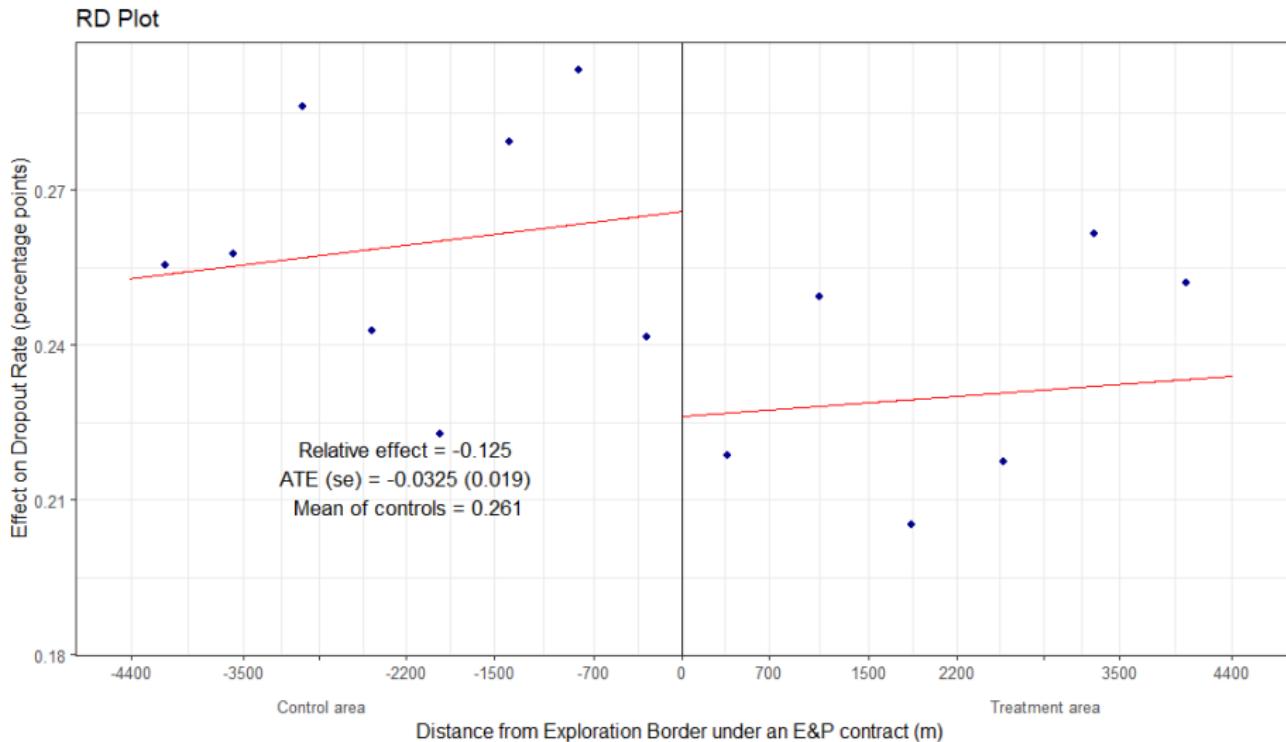
| Method | Coef. | Std. Err. | z | P> z | [95% C.I.] |
|----------------|--------|-----------|--------|-------|-----------------|
| Conventional | -0.049 | 0.011 | -4.357 | 0.000 | [-0.071,-0.027] |
| Bias-Corrected | -0.058 | 0.011 | -5.204 | 0.000 | [-0.080,-0.036] |
| Robust | -0.058 | 0.016 | -3.606 | 0.000 | [-0.090,-0.027] |

Note: The analysis is based on a sample of 5158 observations, with 3157 located within the area of exploration announcement (A^T) and 2001 located near the border but outside the area of exploration (A^C). We employ a Triangular kernel and the variance-covariance matrix estimator is computed with nearest neighbor variance estimator for heteroskedasticity-robust. The global polynomial fit in A^T and A^C is of order 1, the bandwidth where the global polynomial fit is of 4395.556 meters.. We estimate all coefficients using conventional, bias-corrected, and robust estimators, and we cluster standard errors at the school level.

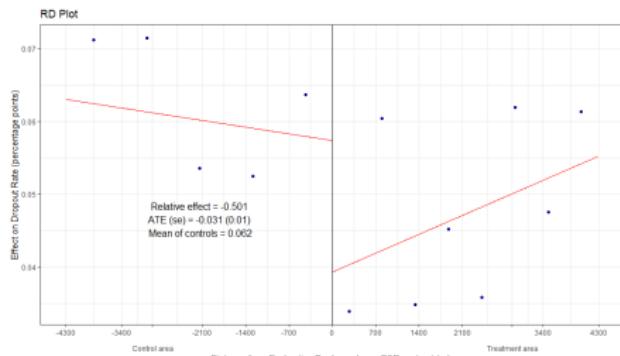
General Result in Elementary School: 1 year after treatment



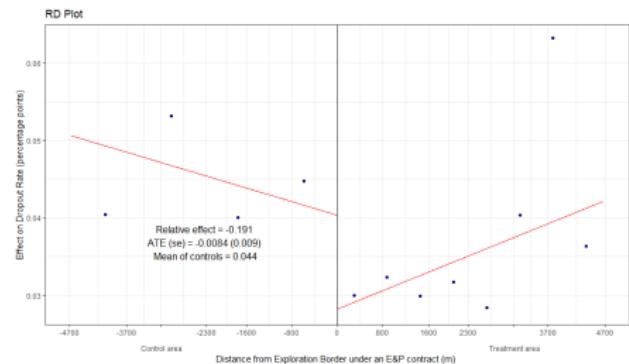
General Result in Elementary School: 2 year after treatment



Dropout in Elementary School by Gender

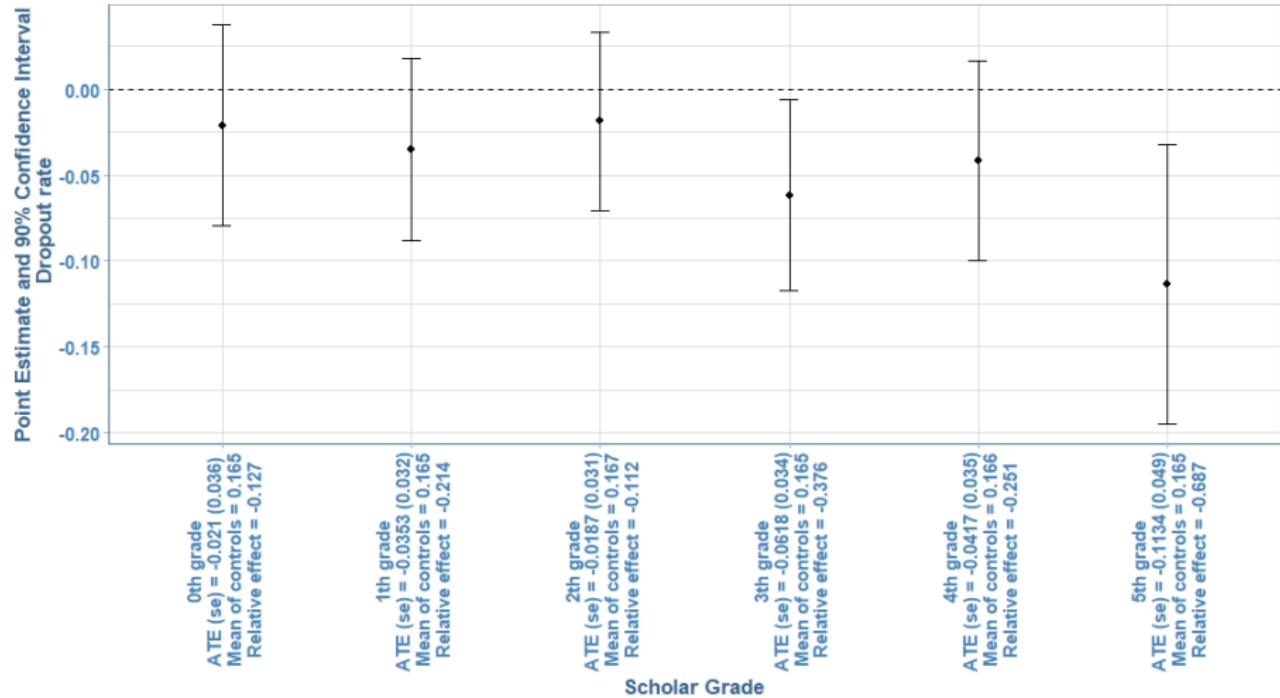


(a). Dropout of Males in Elementary School



(b). Dropout of Females in Elementary School

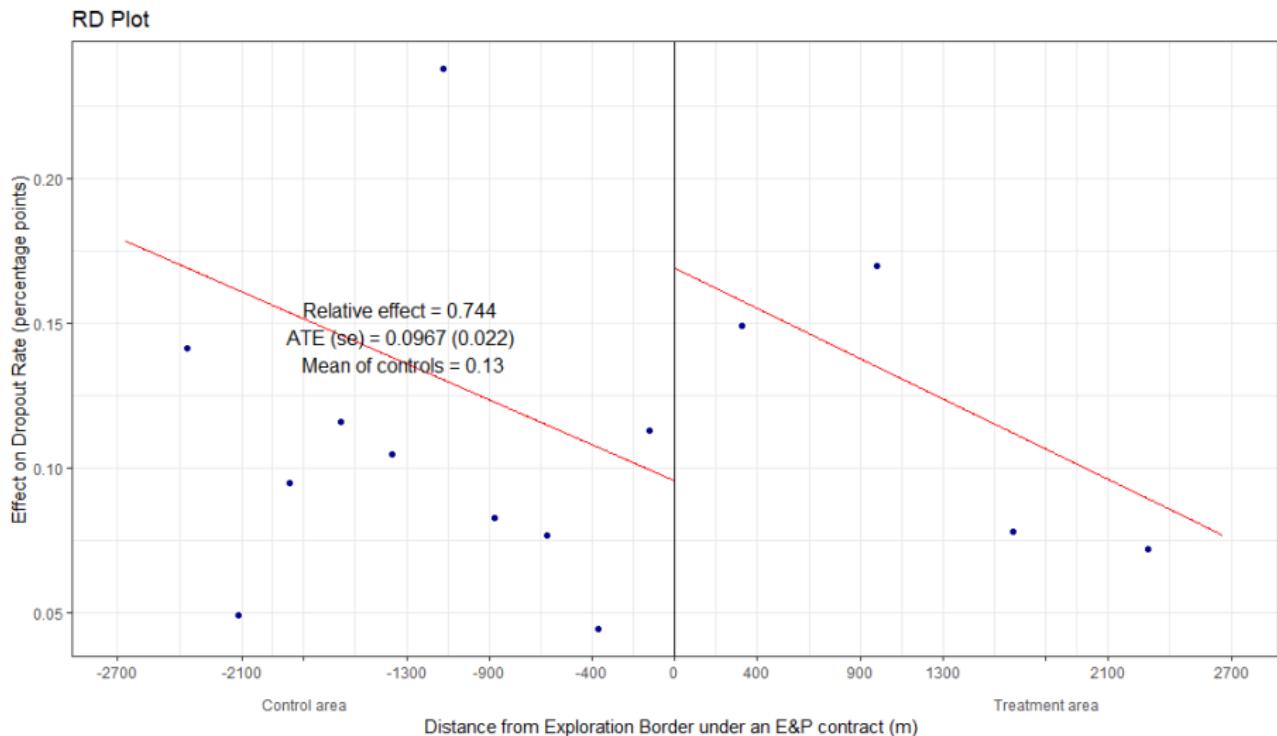
General Inference by Grade in Elementary School



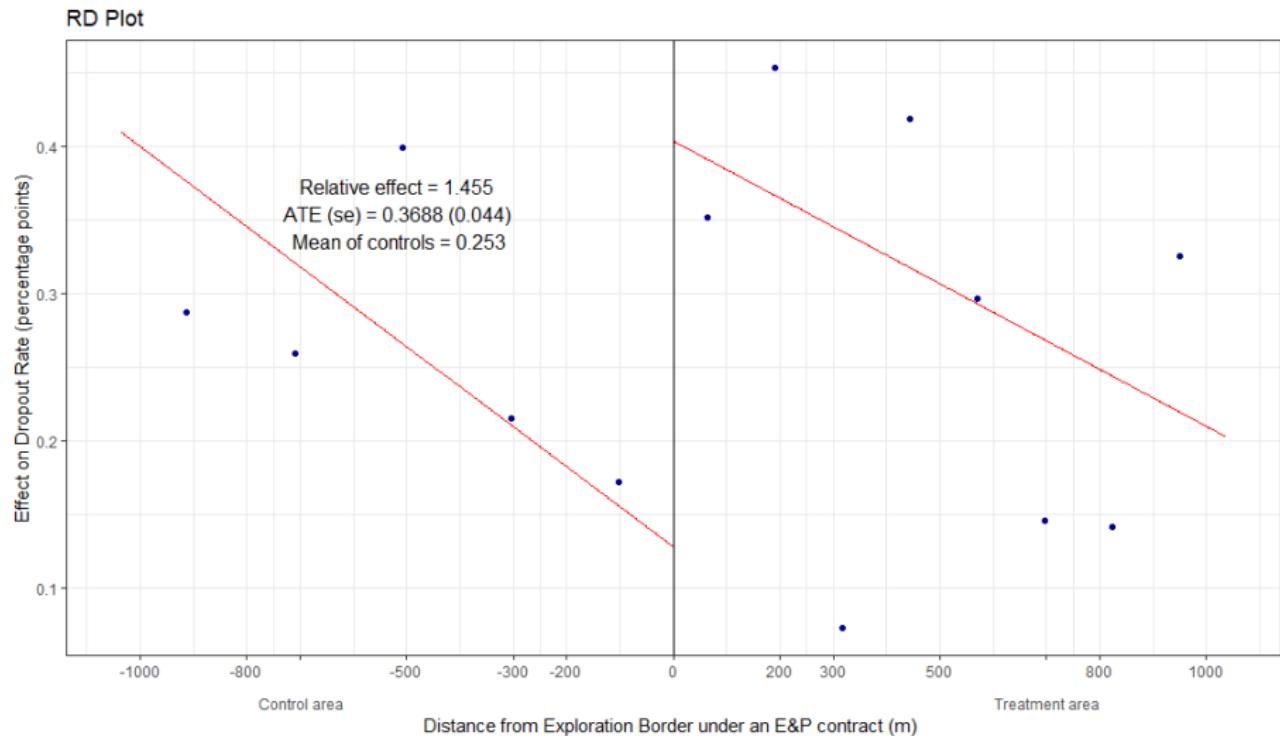
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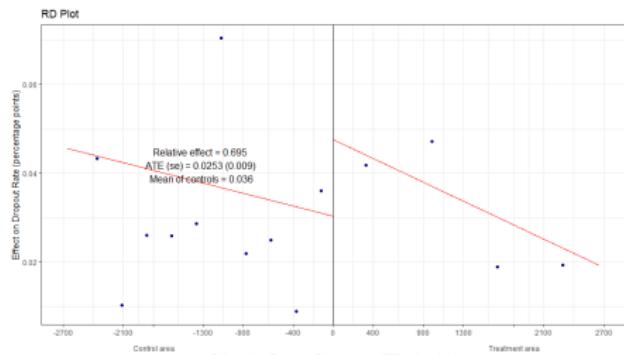
General Result in Secondary School: 1y after treatment



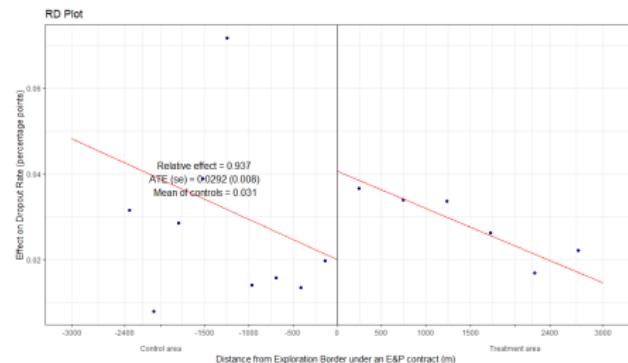
General Result in Secondary School: 2y after treatment



Dropout in Secondary School by Gender

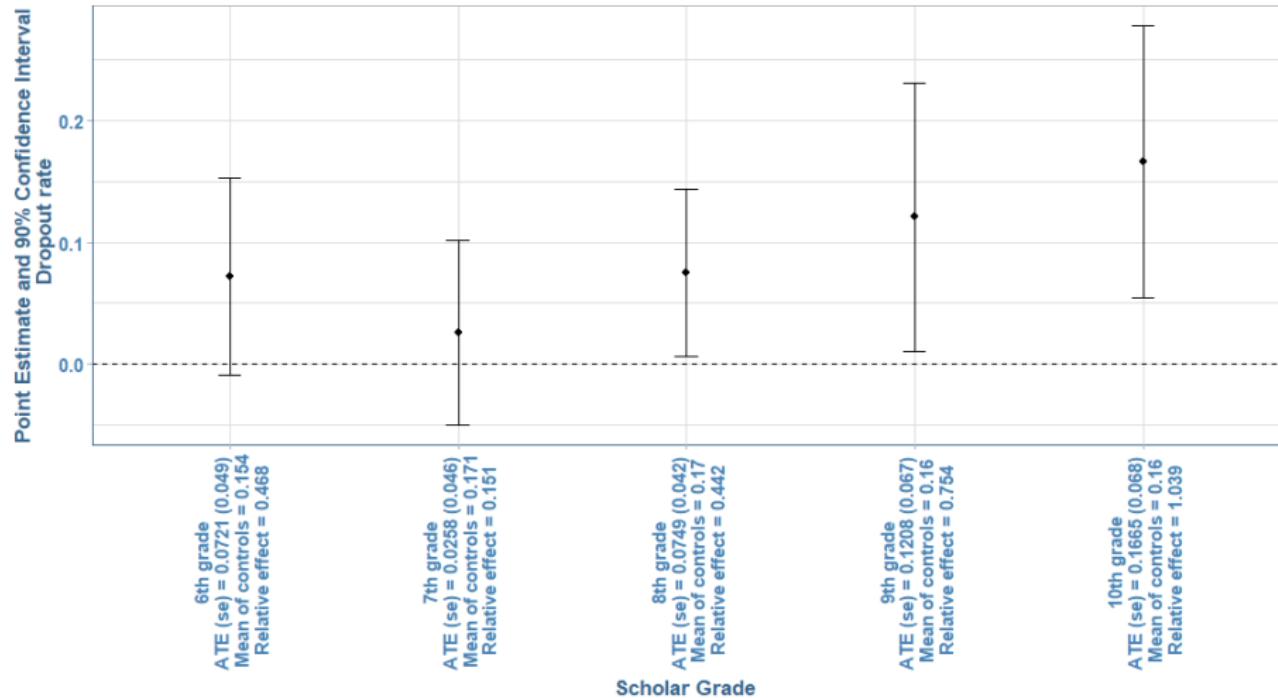


(a). Dropout of Males in Secondary School



(b). Dropout of Females in Secondary School

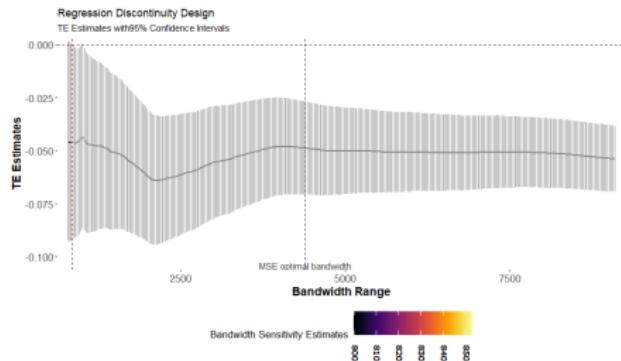
General Inference by Grade in Secondary School



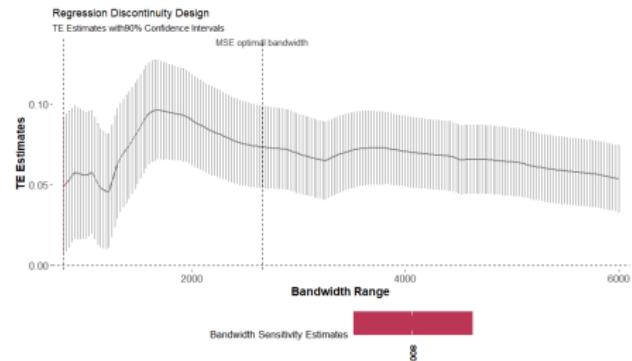
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General Bandwidth sensibility test

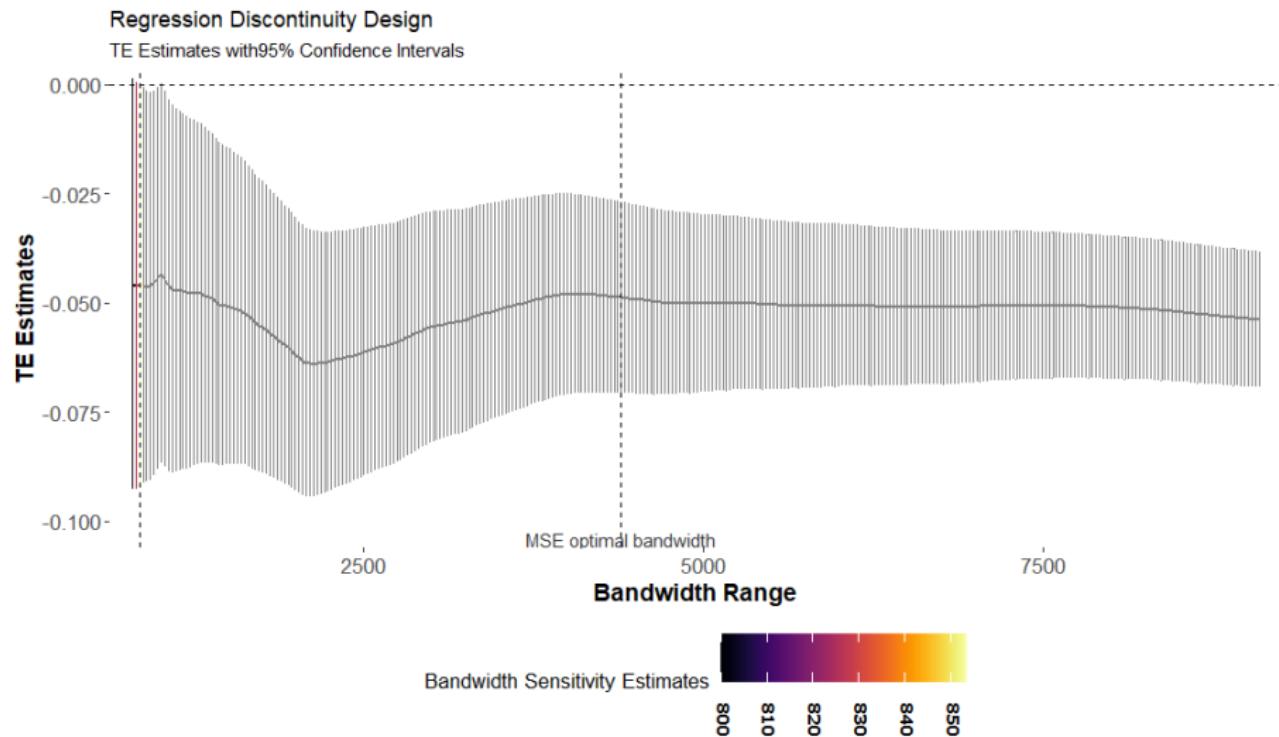


(a). Bandwidth sensibility test of students in Elementary School

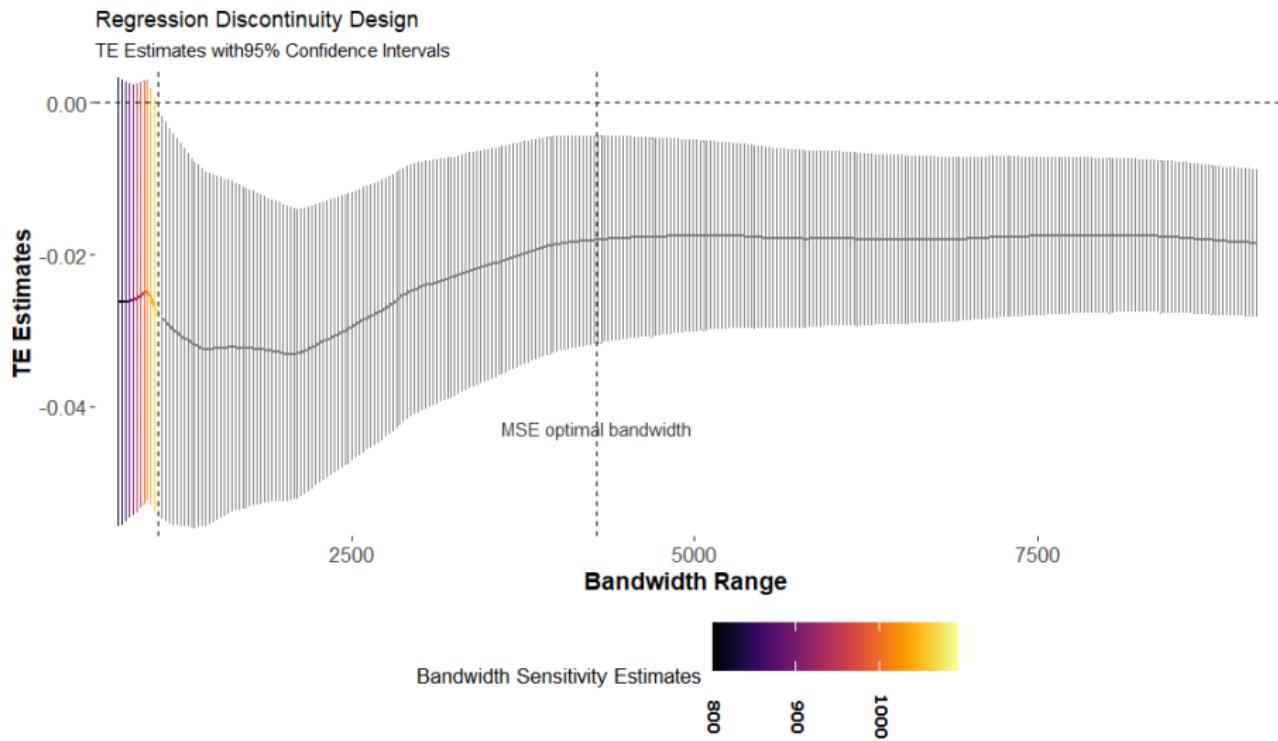


(b). Bandwidth sensibility test of students in Secondary School

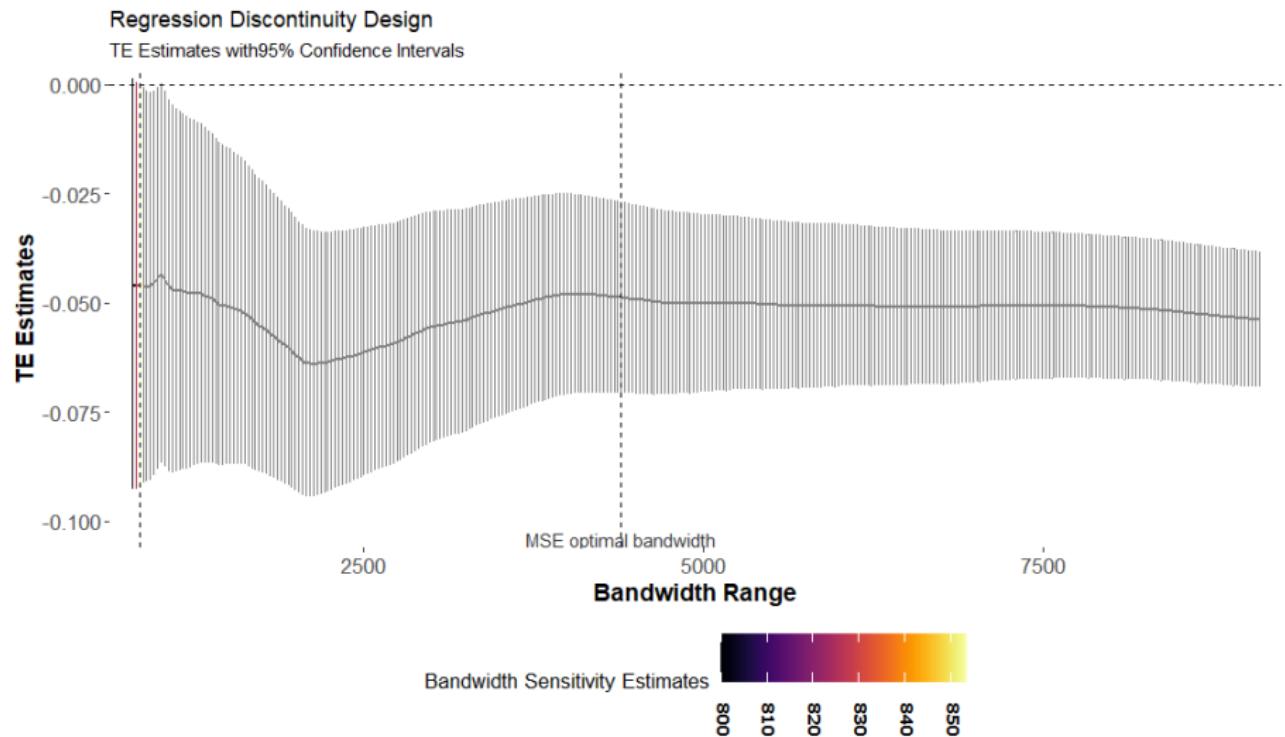
General Bandwidth sensibility test in Elementary School



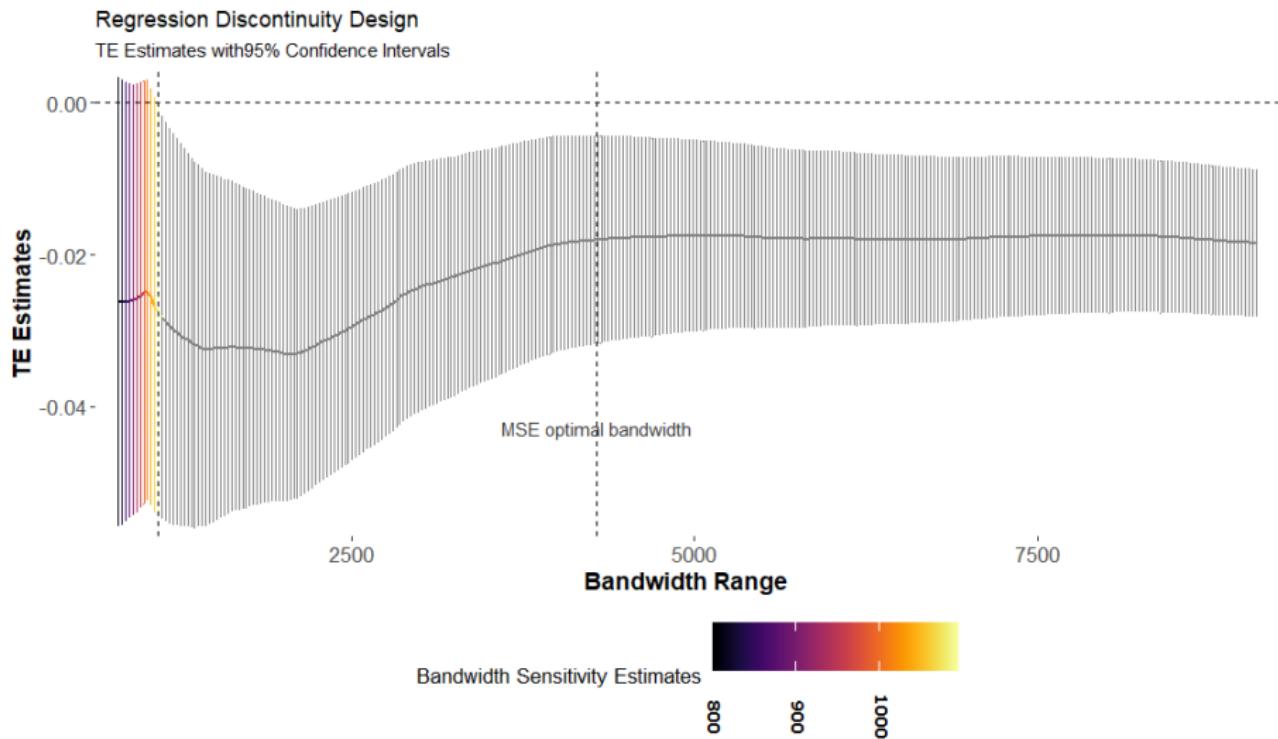
Bandwidth sensibility test of males in Elementary School



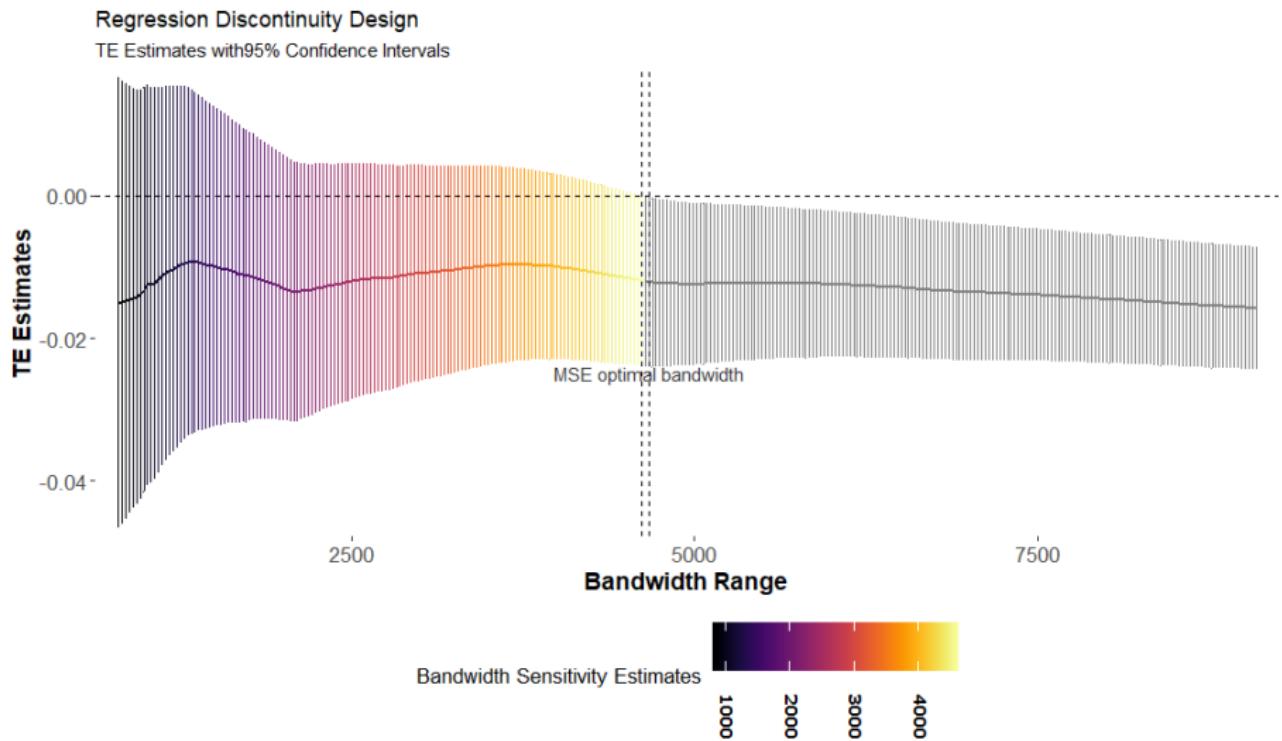
General Bandwidth sensibility test in Elementary School



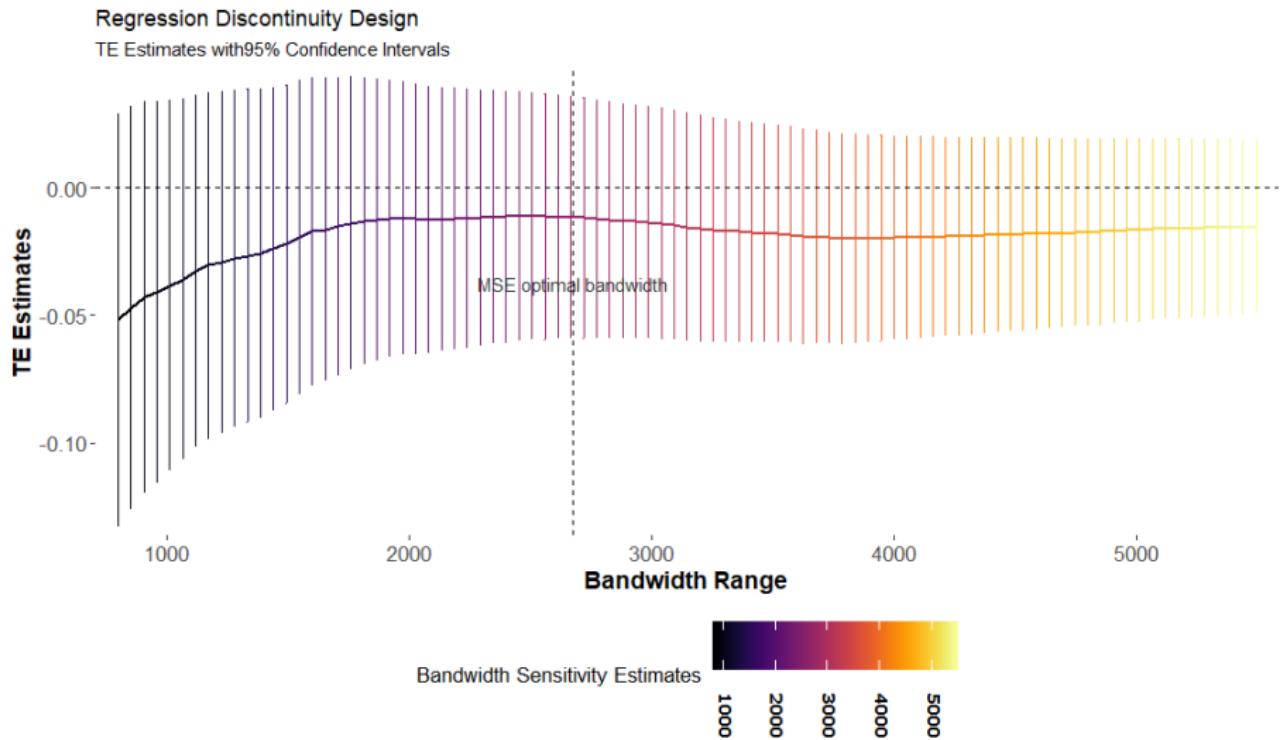
Bandwidth sensibility test of males in Elementary School



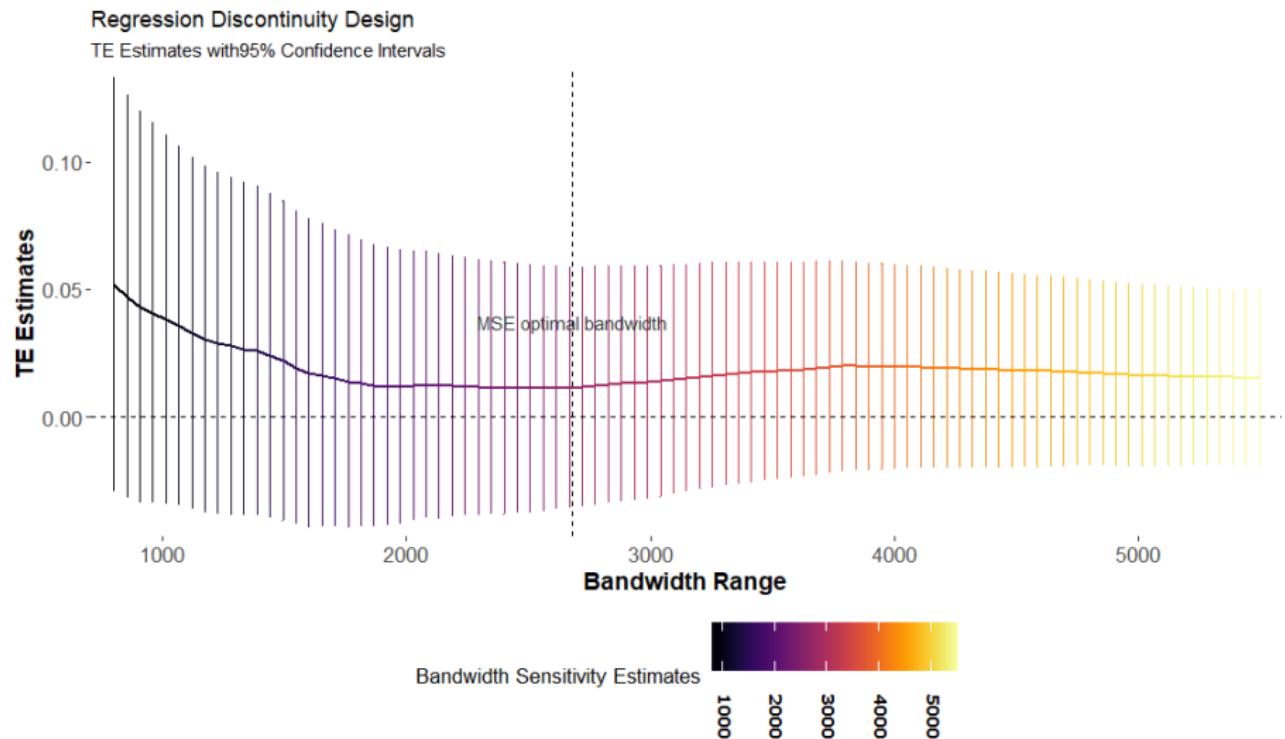
Bandwidth sensibility test of females in Elementary School



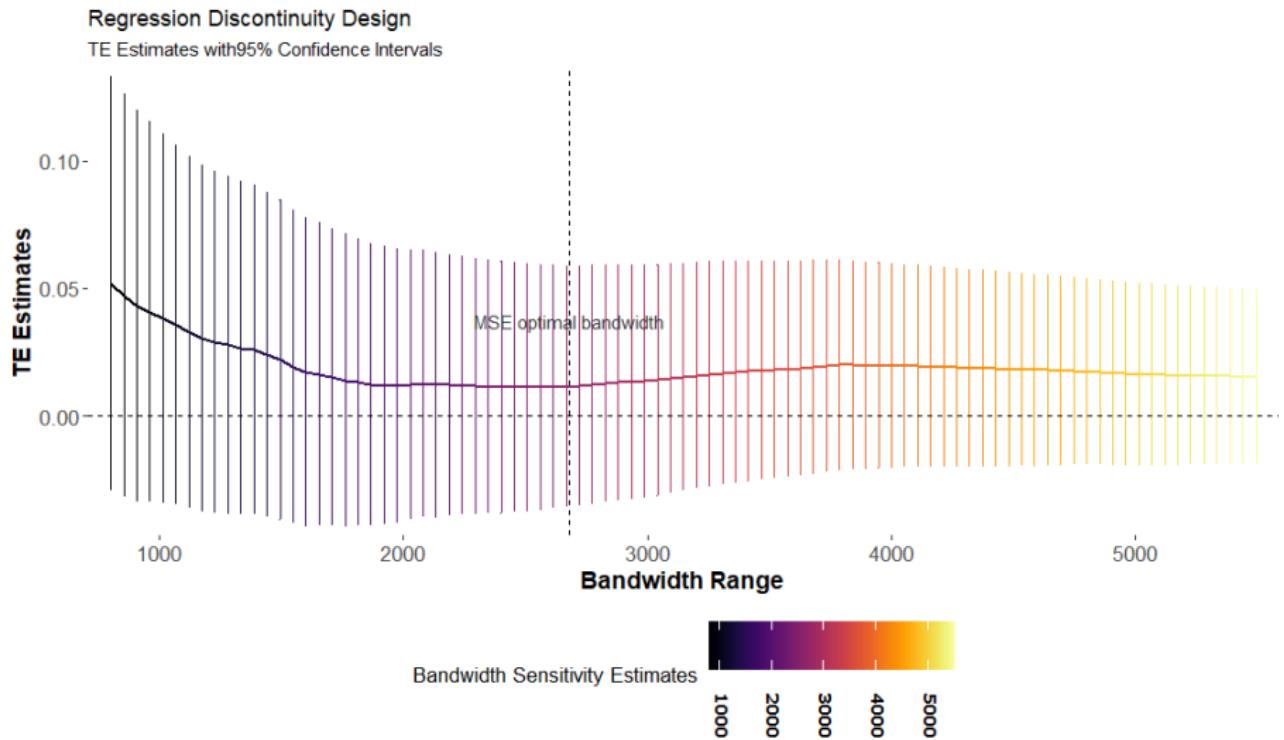
Control and treated schools differ by FRAC FEMALE



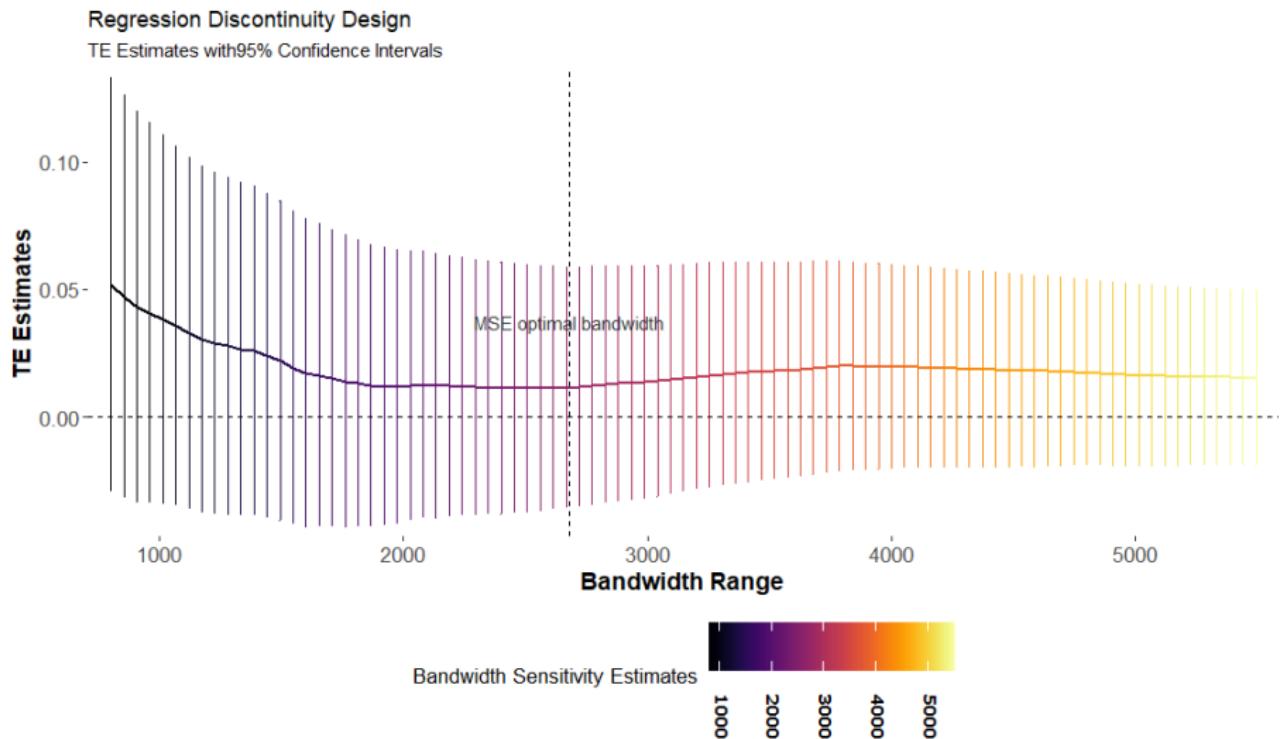
Control and treated schools differ by FRAC MALE



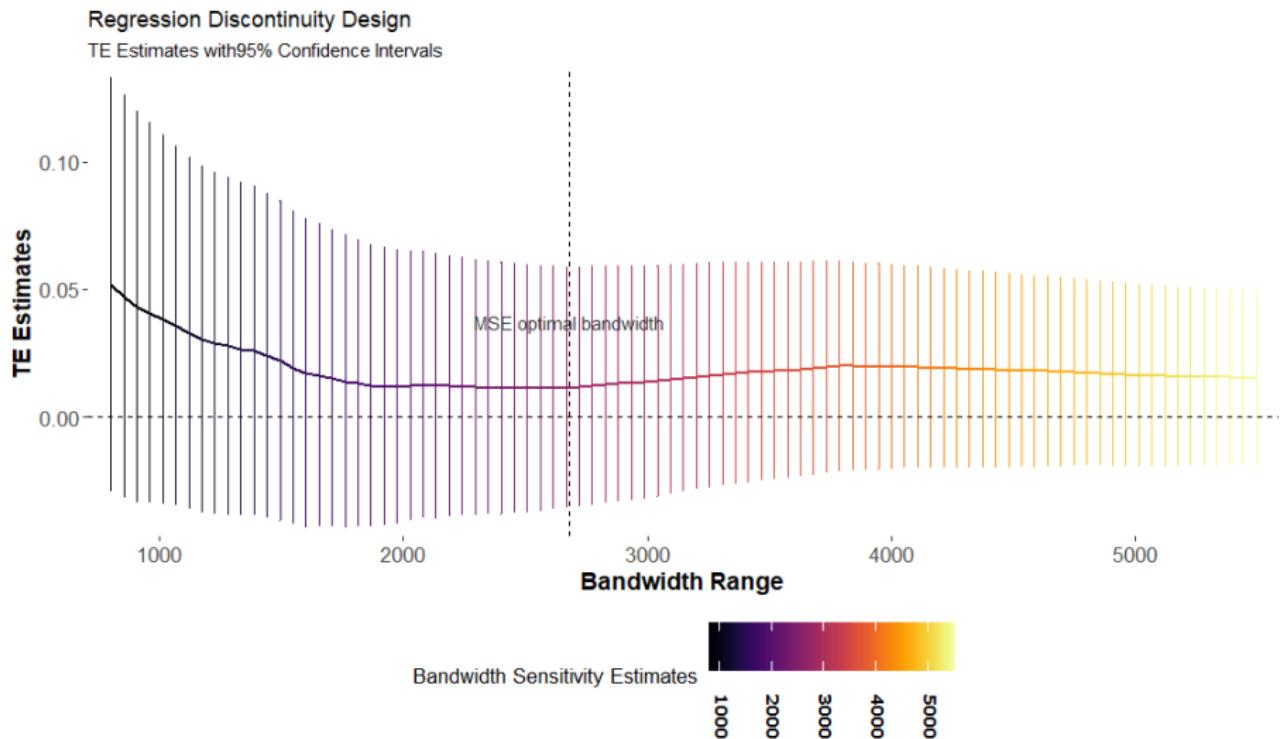
Control and treated schools differ by FRAC NEW STUDENTS



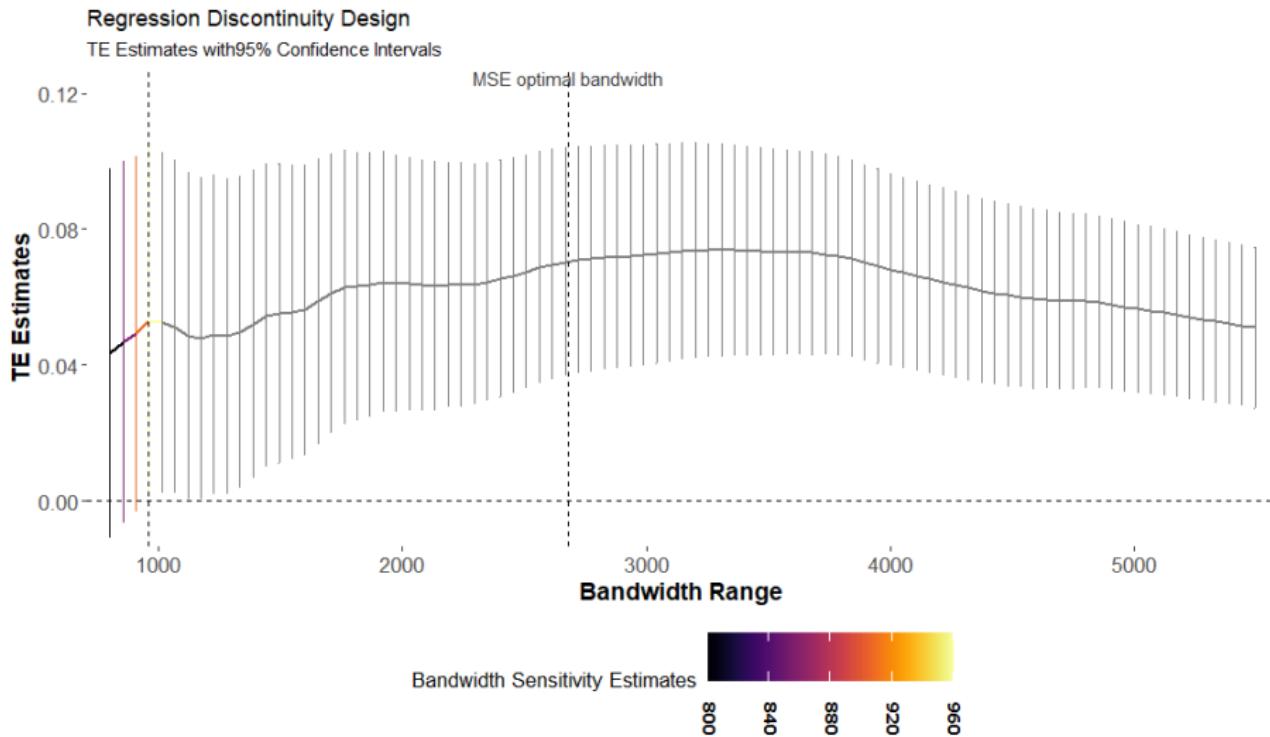
Control and treated schools differ by FRAC REPEATERS



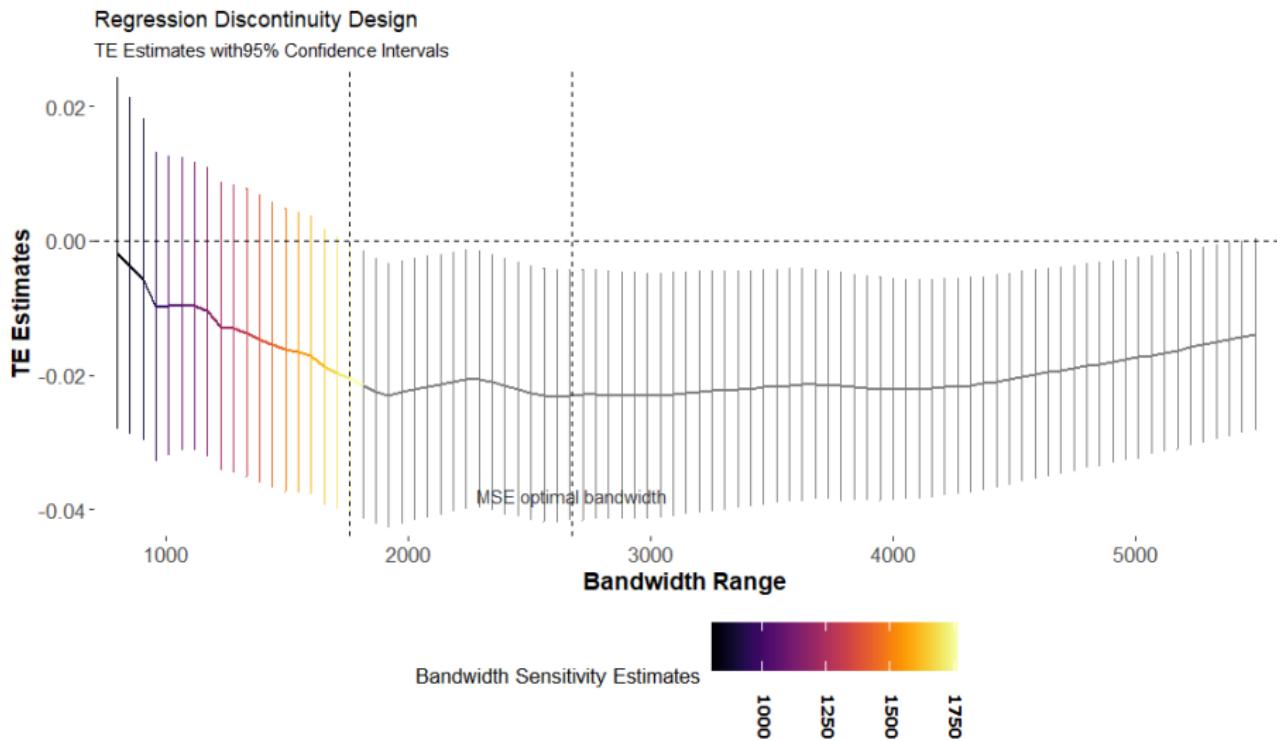
Control and treated schools differ by FRAC SUBSIDIZED



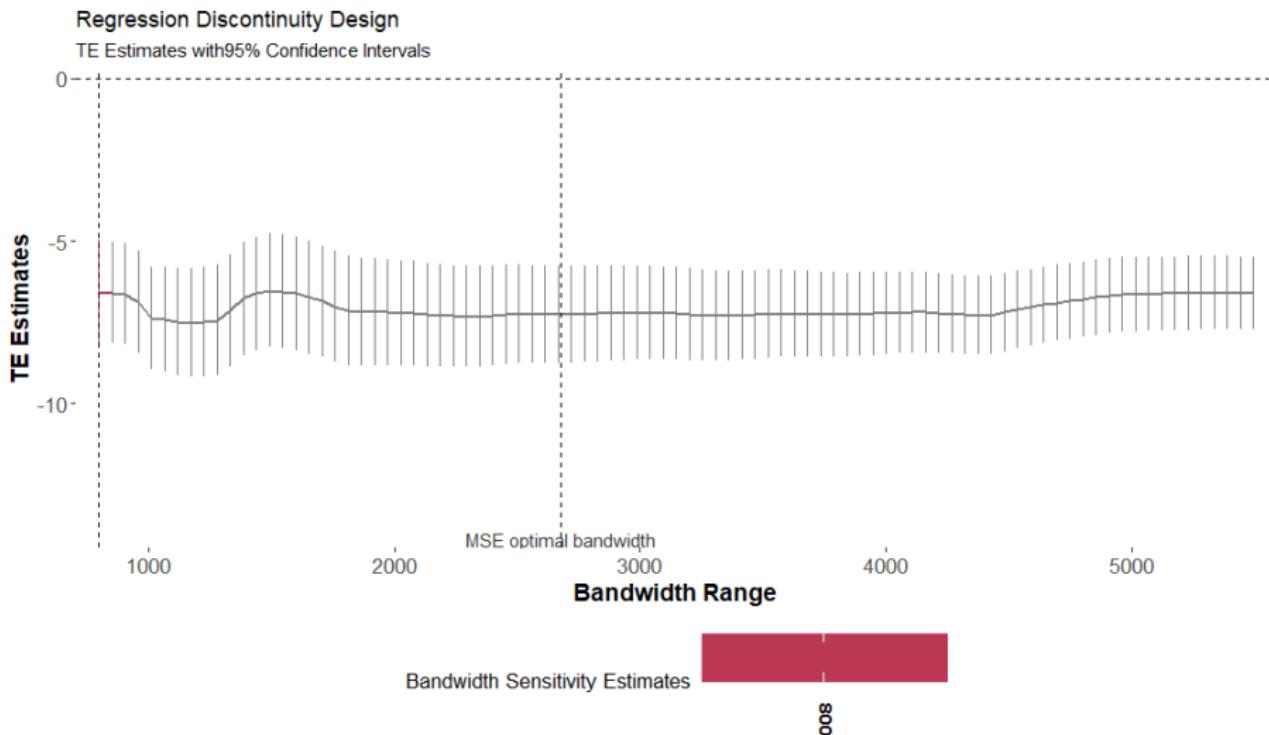
Control and treated schools differ by LOW ECONOMIC LEVEL



Control and treated schools differ by MEDIUM ECONOMIC LEVEL



Control and treated schools differ by AGE



General dropout rate of males in elementary school

| Method | Coef. | Std. Err. | z | P> z | [95% C.I.] |
|----------------|--------|-----------|--------|-------|-----------------|
| Conventional | -0.049 | 0.011 | -4.357 | 0.000 | [-0.071,-0.027] |
| Bias-Corrected | -0.058 | 0.011 | -5.204 | 0.000 | [-0.080,-0.036] |
| Robust | -0.058 | 0.016 | -3.606 | 0.000 | [-0.090,-0.027] |

Note: The analysis is based on a sample of 5158 observations, with 3157 located within the area of exploration announcement (A^T) and 2001 located near the border but outside the area of exploration (A^C). We employ a Triangular kernel and the variance-covariance matrix estimator is computed with nearest neighbor variance estimator for heteroskedasticity-robust. The global polynomial fit in A^T and A^C is of order 1, the bandwidth where the global polynomial fit is of 4395.556 meters.. We estimate all coefficients using conventional, bias-corrected, and robust estimators, and we cluster standard errors at the school level.

General dropout rate of females in elementary school

| Method | Coef. | Std. Err. | z | P> z | [95% C.I.] |
|----------------|--------|-----------|--------|-------|-----------------|
| Conventional | -0.049 | 0.011 | -4.357 | 0.000 | [-0.071,-0.027] |
| Bias-Corrected | -0.058 | 0.011 | -5.204 | 0.000 | [-0.080,-0.036] |
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Note: The analysis is based on a sample of 5158 observations, with 3157 located within the area of exploration announcement (A^T) and 2001 located near the border but outside the area of exploration (A^C). We employ a Triangular kernel and the variance-covariance matrix estimator is computed with nearest neighbor variance estimator for heteroskedasticity-robust. The global polynomial fit in A^T and A^C is of order 1, the bandwidth where the global polynomial fit is of 4395.556 meters.. We estimate all coefficients using conventional, bias-corrected, and robust estimators, and we cluster standard errors at the school level.

Conclusions

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8 Appendix

Literature Review: Do changes in income expectations lead to changes in behavior?

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- Households update their income forecast and adjust consumption plans accordingly. (Das 1997, Roth 2017 and Roth 2018) found that households underestimate their future incomes,
- Jappelli 2009: Further research is needed to more fully understand the relationship between income expectations and behavior.
- Armantier 2011: Survey respondents act on inflation expectations, irrationals have lower education and financial literacy.
- Das 1999: Respondents form rational expectations, reported expectations are best future predictions.

Literature Review: How do income expectations affect the decision to attend college? [return to the summary!](#)

- ▶ There is a weak link between expectations and realizations among low-income (particularly minority) youth. (Rouse, 2004)
- ▶ Unrealistic expectations regarding their futures may explain the weak link between expectations and realizations among low-income (particularly minority) youth. (Rouse, 2004)
- ▶ Income expectations play a small role in university choice, while non-pecuniary factors are major determinants. (Delavande and Zafar, 2014, 2019)
- ▶ Lower-income students are more likely to be restricted in their postsecondary opportunities due to their perceptions of college costs. (Paulsen and St. John, 2002)
- ▶ Labor market prospects play a small role in university choice in some countries, such as Pakistan, while nonpecuniary outcomes, such as the school's ideology, are the major determinants. (Delavande and Zafar, 2019)
- ▶ Poor individuals require higher expected returns to be induced to attend college than individuals from rich families. (Kaufmann, 2014)
- ▶ Nonpecuniary factors are a key determinant of schooling choices. (Beffy et al., 2019)

Literature Review: What is the effect of income changes on academic performance?

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[return to the Model for Study Time!](#)

- Duncan 2011: A \$1,000 increase in annual income raises young children's achievement by 5%-6% of a standard deviation.
- Dahl 2008: A \$1,000 increase in income raises math and reading test scores by 6% of a standard deviation in the short-run.
- Chmielewski 2016: US income achievement gap larger than other countries.
- Carlisle 2015: Socioeconomic segregation, school funding, teacher expectations, and academic climate affect academic achievement.

Literature Review: What is Impact of Oil exploration and production on academic performance?

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- Laska 1993: Offshore oil and gas production has both positive and negative impacts on social institutions, which may impact academic performance.
- Zuo 2019: Intensive drilling activities decreased grade 11 and 12 enrollment, suggesting a negative impact of oil production on academic performance.
- Akinwale 2020: Low level of interactions between indigenous firms in oil industry and university in Nigeria may impact academic performance.
- Kharaka 2005: Oil production can cause local detrimental impacts to soils, surface and ground-waters, and ecosystems, which may impact academic performance.
- Perry 2012:

Literature Review: What is the impact of external infrastructure interventions on schooling decisions?

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- Barrett 2018: School facilities affect children's learning outcomes.
- Fisher 2001: School infrastructure affects student outcomes and behavior.
- Cuesta 2016: School libraries and new schools improve learning and enrollment.
- Belmonte 2020: Investment in school infrastructure affects students' achievement.

| Variable | level | mean.of.treated | mean.of.control | Difference |
|-------------------|------------|-----------------|-----------------|-----------------|
| FEMALE DROPOUT T2 | Secondary | 0.12 (0.13) | 0.12 (0.14) | 0.002 (-0.011) |
| MALE DROPOUT T2 | Secondary | 0.13 (0.12) | 0.13 (0.15) | -0.003 (-0.025) |
| DESERTO T2 | Secondary | 0.48 (0.38) | 0.47 (0.38) | 0.014 (0.005) |
| FEMALE DROPOUT T1 | Secondary | 0.07 (0.11) | 0.08 (0.12) | -0.003 (-0.012) |
| MALE DROPOUT T1 | Secondary | 0.08 (0.11) | 0.08 (0.12) | -0.002 (-0.018) |
| DESERTO T1 | Secondary | 0.28 (0.34) | 0.28 (0.34) | 0.002 (0) |
| EDAD | Secondary | 32.9 (31.2) | 32.01 (35.72) | 0.891 (-4.515) |
| FRAC ESTRATO 3 4 | Secondary | 0.06 (0.15) | 0.02 (0.09) | 0.036 (0.067) |
| FRAC ESTRATO 1 2 | Secondary | 0.86 (0.22) | 0.9 (0.17) | -0.046 (0.043) |
| FRAC SUBSIDIADO | Secondary | 0.51 (0.11) | 0.51 (0.14) | -0.004 (-0.026) |
| FRAC REPITENTE | Secondary | 0.51 (0.11) | 0.51 (0.14) | -0.004 (-0.026) |
| FRAC NUEVO | Secondary | 0.51 (0.11) | 0.51 (0.14) | -0.004 (-0.026) |
| FRAC MALE | Secondary | 0.51 (0.11) | 0.51 (0.14) | -0.004 (-0.026) |
| FRAC FEMALE | Secondary | 0.49 (0.11) | 0.49 (0.14) | 0.004 (-0.026) |
| FEMALE DROPOUT T2 | Elementary | 0.06 (0.13) | 0.07 (0.15) | -0.008 (-0.017) |
| MALE DROPOUT T2 | Elementary | 0.08 (0.16) | 0.1 (0.18) | -0.019 (-0.025) |
| DESERTO T2 | Elementary | 0.23 (0.3) | 0.27 (0.3) | -0.033 (-0.008) |
| FEMALE DROPOUT T1 | Elementary | 0.03 (0.11) | 0.05 (0.13) | -0.011 (-0.02) |
| MALE DROPOUT T1 | Elementary | 0.05 (0.12) | 0.06 (0.14) | -0.014 (-0.017) |
| DESERTO T1 | Elementary | 0.13 (0.22) | 0.17 (0.24) | -0.037 (-0.025) |
| EDAD | Elementary | 13.59 (19.55) | 13.98 (26.07) | -0.388 (-6.523) |
| FRAC ESTRATO 3 4 | Elementary | 0.03 (0.12) | 0.01 (0.08) | 0.017 (0.039) |
| FRAC ESTRATO 1 2 | Elementary | 0.86 (0.25) | 0.9 (0.21) | -0.038 (0.041) |
| FRAC SUBSIDIADO | Elementary | 0.53 (0.22) | 0.54 (0.23) | -0.006 (-0.009) |
| FRAC REPITENTE | Elementary | 0.53 (0.22) | 0.54 (0.23) | -0.006 (-0.009) |
| FRAC NUEVO | Elementary | 0.53 (0.22) | 0.54 (0.23) | -0.006 (-0.009) |
| FRAC MALE | Elementary | 0.53 (0.22) | 0.54 (0.23) | -0.006 (-0.009) |
| FRAC FEMALE | Elementary | 0.47 (0.22) | 0.46 (0.22) | 0.006 (-0.002) |