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

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https://github.com/polanco-jaime/black_gold_and_dull_minds

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Why This Study Matters

- There are more than 65,000 oil fields around the world, in Colombia:.
  - Today Colombia has 157 gas and oil fields (128 produce gas and 146 produce oil).
  - Colombia is the fourth largest oil producer in South America, after Venezuela, Brazil, and Ecuador.
  - Colombia is the fifth largest natural gas producer in South America, after Venezuela, Argentina, Bolivia, and Peru.
  - The oil and gas industry accounts for about 3% of Colombia's GDP and employs about 100,000 people.
- The literature on oil and gas industry highlights a mixed impact on education. [1]
- In Colombia, the effect of each stage on education has not yet been evidenced.But Since 2012:
  - 985 schools have been affected
  - 120260 students in elementary school have been affected[2].
  - 95190 students in secondary school have been affected [3].

[1] While the presence of oil fields may negatively affect education (Farzanegan and Thum (2018) , Marchand and Weber (2018) , (Farzanegan, 2017) , Genareo (2018) , Zuo, Schieffer, and Buck (2019)), oil revenues have the potential to positively impact ed- ucation by providing funding for improving its quality and promoting human capital development (Maciel (2021) , Kumar (2017)).

[2] 2.46% of all students in elementary school

[3] 2.28% of all students in secondary school

Problem Statement.

Research question : 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.

$$HEA^{4} \Rightarrow \uparrow \underbrace{E\left[w_h\right]}_{\text{expected family income}} \Rightarrow \underbrace{\Delta F}_{\text{Student's family attributes}} \Rightarrow \underbrace{\Delta S_t}_{\text{Student's attributes}} \Rightarrow$$

$$\underbrace{\Delta s}_{\text{Student's studying time}}$$

[4] Where HEA is the Hydrocarbon Exploration Announcements

Contributions to Literature

- Contribute to the literature on natural resource, evaluating the impact of expected hydrocarbon exploitation on human capital accumulation.
- We provide empirical evidence of the effect of the announcement of hydrocarbon exploration on the following variables:
  - Schooling decisions.
  - Academic performance.
  - Student mobility.
- Software: Python framework designed to facilitate the calculation of geographic distances for economic researchers. **View on GitHub**

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
- Heterogeneous effects by gender.
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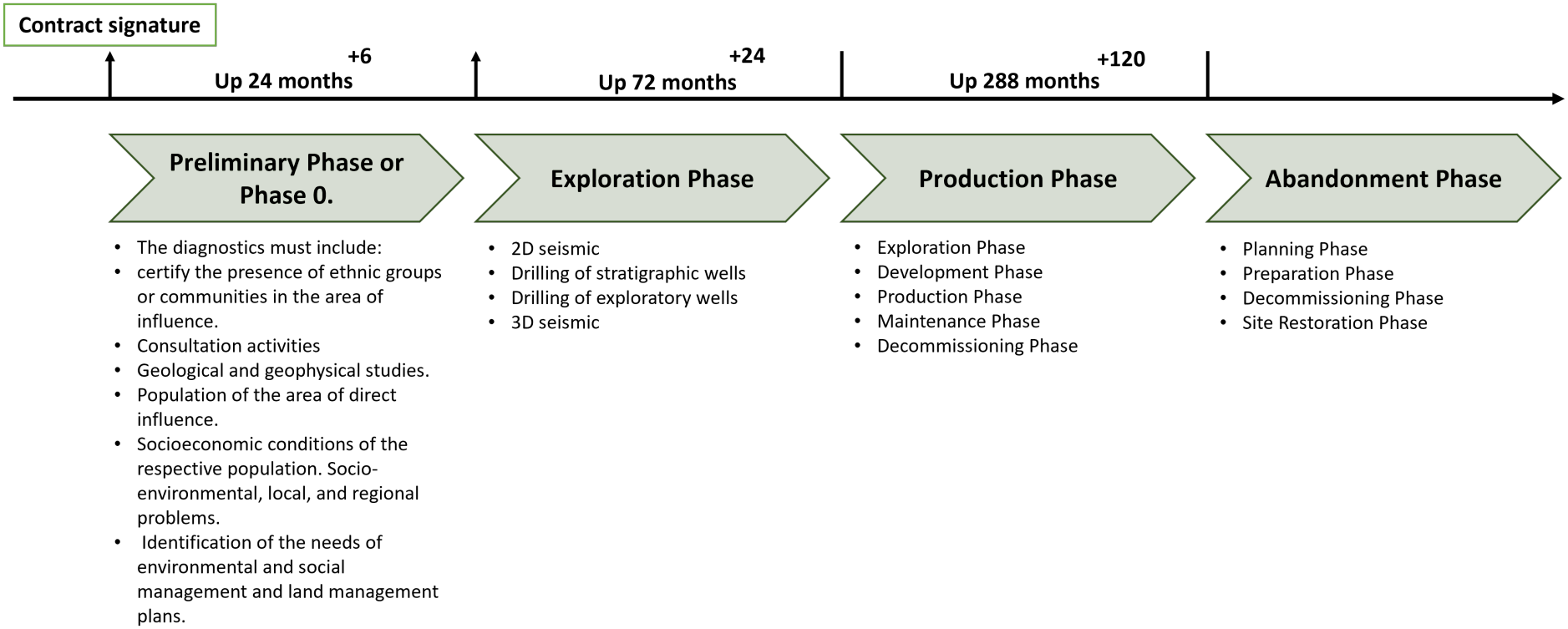
Exploration and Production (E&P) Contract in Colombia

- 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

The context of hydrocarbon exploitation in Colombia.

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

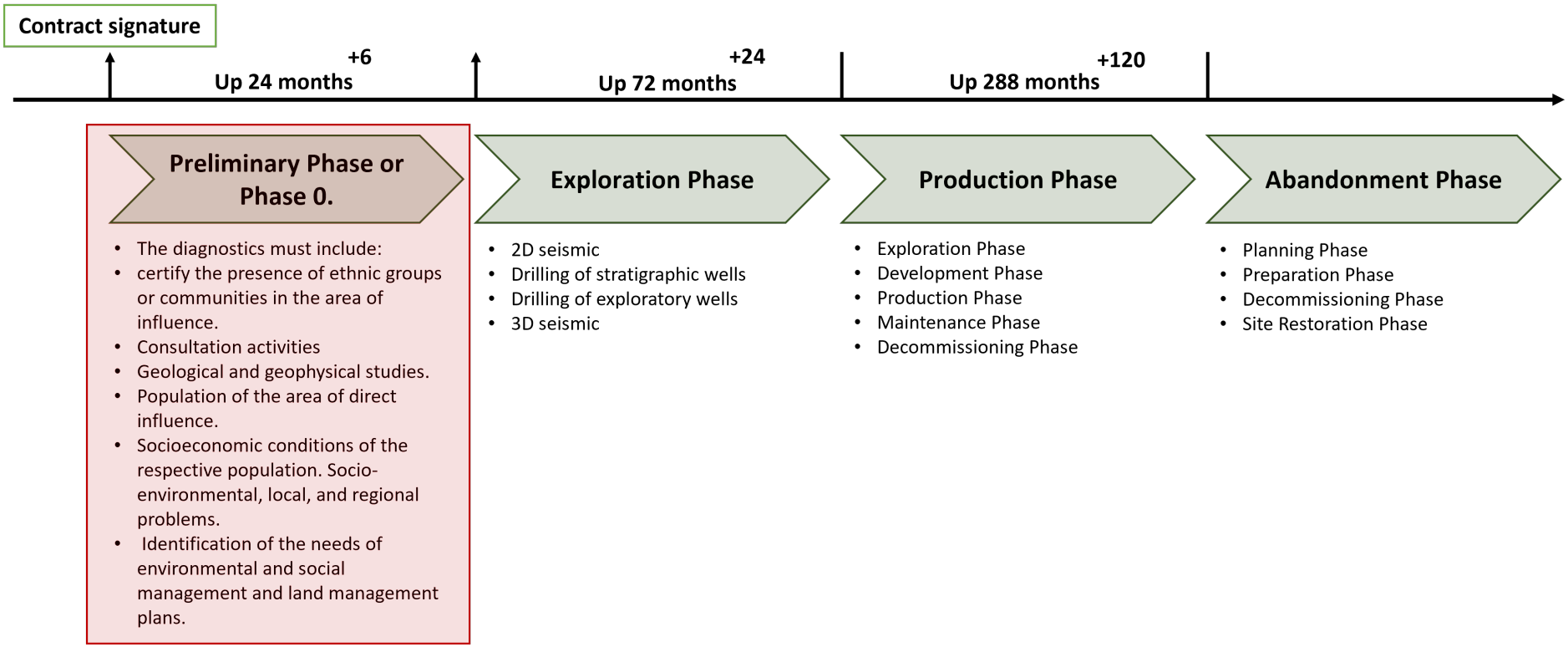


Key Points:

- 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

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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.[5] . 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.[6] see more!
- Income changes: A $1,000 increase in annual income raises young children's achievement by 5%-6% of a standard deviation[7]. 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. [8]. see more!
- External infrastructure interventions: School facilities, libraries, and new schools can improve learning, enrollment, and student outcomes [9]. see more!

[5] Authors: Das 1997, Roth 2017, and Roth 2018
[6] Authors: Rouse 2004, Bosworth 1985, Beffy 2012,Smith 1990
[7] Authors: Duncan 2011, Dahl 2008
[8] Authors: Zuo 2019, Laska 1993
[9] Authors: Barrett 2018, Fisher 2001, Cuesta 2016, and Belmonte 2020

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Model for Educational Institution

We assume that the educational institution operates under perfect competition and aims to maximize profits subject to the production function and the prices of the inputs:

$$\max_{S,F,Sc} P(Y)Y - w_S S - w_F F - w_{Sc} Sc$$

where $P(Y)$ is the price of the educational outcome, Y, and w_S, w_F, and w_{Sc} are the prices of study time, family attributes, and educational institution attributes, respectively.

Model for Educational Outcome

We assume that the educational outcome, Y, is a function of the student's family attributes, F, the student's attributes, St, and the educational institution's attributes, Sc. Specifically, we assume that[10]:

$$Y = f(F, St, Sc) + \epsilon$$

where ϵ is a random error term.

What happens when the income expectations of the students' families change, or the motivation of the students changes?

[10] Hanushek (1979); Vignoles, Levacic et al. (2000); Todd and Wolpin (2003); Meyer and Nascimento (2008)

Model for Study Time

We assume that the amount of study time, S, is a function of the student's family income, I_F, and the student's own personal characteristics, St. Specifically, we assume that: see more!

$$S = g(I_F, St) + \eta$$

where η is a random error term.

Model for Family Income

We assume that family income, I_F, is a function of the parents' education, E_P, the parents' income, I_P, and the parents' involvement in the student's education, Inv_P. Specifically, we assume that the family income for students of elemenary school is not related to Student's Personal Characteristics (pupils doesn't have incomes) while students of secondary students can help improve parents' income. Then we assume: Model for Family Income of students in in elementary school:

$$I_F = h(E_P, I_P, Inv_P) + \nu$$

Model for Family Income of students in in elementary school:

$$I_F = h(E_P, I_P, Inv_P, St) + \nu$$

where ν is a random error term.

Model for Student's Personal Characteristics

We assume that the student's personal characteristics, St, are a function of the student's intelligence, I_S, motivation, M_S, and study habits, H_S. Specifically, we found that [11] St in elementary school is related to I_F while in secondary school this relation is weaker. Then we assume:
Model for Student's Personal Characteristics in elementary school:

$$St = j(I_S, M_S, H_S, I_F) + \mu$$

Model for Student's Personal Characteristics in secondary school:

$$St = j(I_S, M_S, H_S) + \mu$$

[11] Steinmayr et.al 2019; Harris, D. N. 2010

Model for Change in Study Time with Respect to Family Income

To see how the amount of study time changes with respect to family income in elementary and secondary school, we need to take the derivative of S with respect to IF separately for both models.
Taking the derivative of S with respect to IF, we get:

$$\frac{dS}{dI_F} = \frac{\partial g}{\partial I_F} + \frac{\partial g}{\partial St}\frac{dSt}{dI_F}$$

Elementary School Students

Since we assume that family income for elementary school students is not related to the student's personal characteristics, we have:

$$\frac{dSt}{dI_F} = 0$$

Thus, the derivative simplifies to:

$$\frac{dS}{dI_F} = \frac{\partial g}{\partial I_F}$$

Model for Change in Study Time with Respect to Family Income

To see how the amount of study time changes with respect to family income in elementary and secondary school, we need to take the derivative of S with respect to IF separately for both models. Taking the derivative of S with respect to IF, we get:

$$\frac{dS}{dI_F} = \frac{\partial g}{\partial I_F} + \frac{\partial g}{\partial St}\frac{dSt}{dI_F}$$

Secondary School Students

Since we assume that family income for secondary school students can help improve parents' income, we have:

$$\frac{dSt}{dI_F} > 0$$

Thus, the derivative simplifies to:

$$\frac{dS}{dI_F} = \frac{\partial g}{\partial I_F} + \frac{\partial g}{\partial St}\frac{dSt}{dI_F} > \frac{\partial g}{\partial I_F}$$

Model for Change in Study Time with Respect to Family Income

In summary we have:

Change in Study Time with Respect to Family Income of Students in Elementary School:

$$\frac{dS}{dI_F} = \frac{\partial g}{\partial I_F}$$

Change in Study Time with Respect to Family Income of Students in Secondary School:

$$\frac{dS}{dI_F} > \frac{\partial g}{\partial I_F}$$

This means that the effect of family income on study time is likely to be stronger for secondary school students than for elementary school students.

$$\underbrace{\uparrow \Delta F}_{\text{Student's family attributes}} \quad \Rightarrow \quad \underbrace{\Delta s}_{\text{Student's studying time}}$$

where: $\Delta s_{secondary} > \Delta_{s\,Elemenary}$

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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 0.0

* If potential outcomes are random, then randomized experiments imply:
$E[Y_i|HEA = 1] - E[Y_i|HEA = 0] =$
$E[Y_i(1)|HEA = 1] - E[Y_i(0)|HEA = 0] =$
$E[Y_i(1)|HEA = 1] - E[Y_i(0)|HEA = 1] + \text{Bias}$
BIas is Zero $E[Y_i(0)|HEA = 1] - E[Y_i(0)|HEA = 0]$[a]
* Under randomization, all characteristics (observed or unobserved) will be similar between control and treatment units. $\Rightarrow$
$\tau_{ATE} = \tau_{ATET} = E[Y_i(1) - Y_i(0)] = E[Y_i(1) - Y_i(0)|Exploration = 1]$

[a] HEA is the Hydrocarbon Exploration Announcements

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 : Assumption 1.

onditional 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 di being the (shortest) distance to the border and D a specified maximum distance to the border

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.
The exploration areas auctioned in an EP 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 : 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:

$$\nexists B \subseteq AT, \forall G \in G \backslash \{AT\} : B \subseteq G.$$

This means that there is no subset B of AT that is also a subset of any other geography G in G except for AT itself. In other words, the border between B and AT is unique and does not overlap with any other area.

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 : Assumption 2.

Compound Treatment Irrelevance Assumption (Keele and Titiunik 2016):

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 : 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:

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

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

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

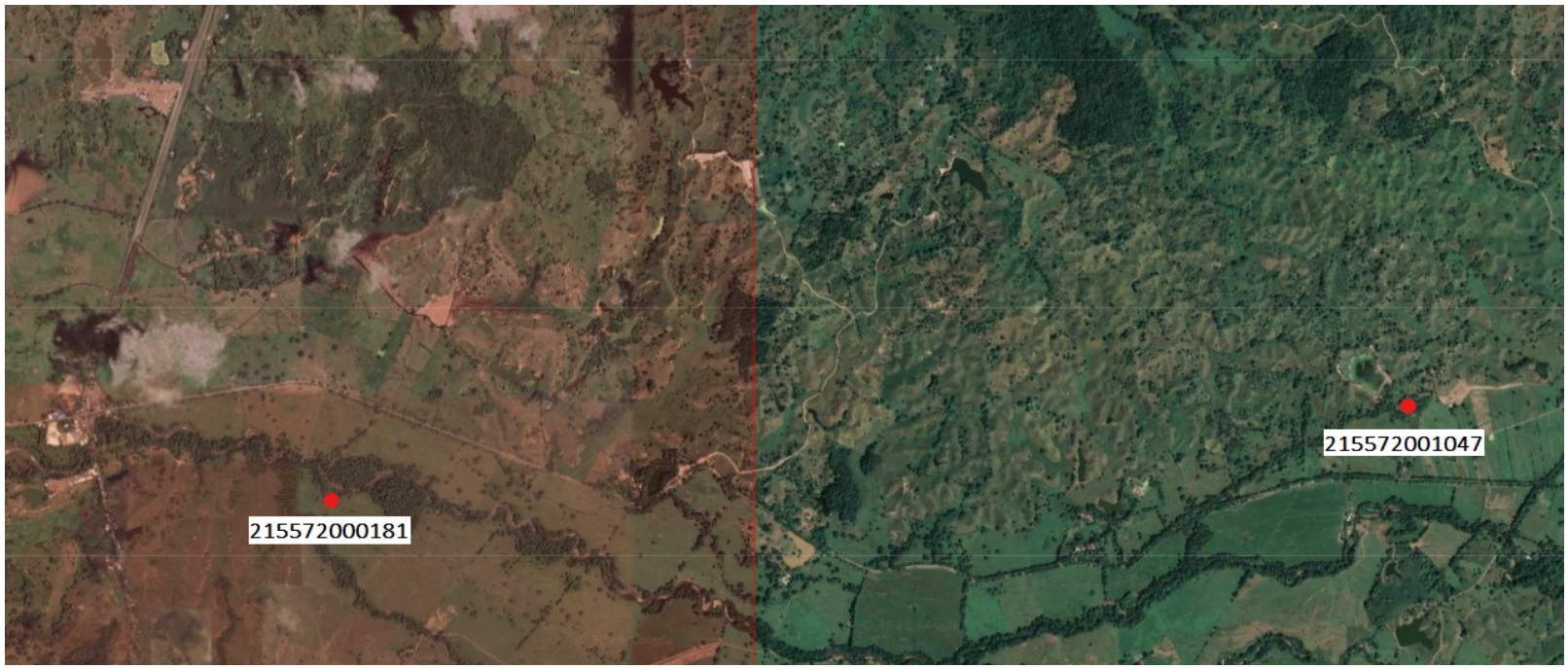
Perpendicular euclidean distance to the boundary does not mask important heterogenities.

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.

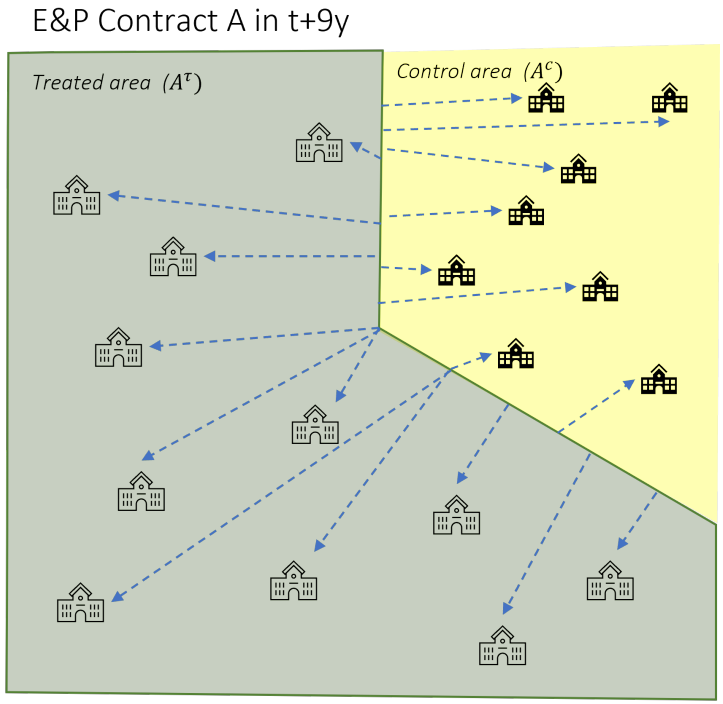
Analysis : Assumption 3.

Naive distance (Keele and Titiunik 2016):



Perpendicular euclidean distance to the boundary does not mask important heterogenities.

Geographic Regression Discontinuity (GRD) Design



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

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 $i \in A^\tau$
- X_i is a set of covariates that may affect the outcome variable
- α, β_1 ,β_2, and η are parameters to be estimated
- ε_i is an error term.

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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)
- Standardized test Saber 11 from 2012 to 2020, (ICFES)
- Georeferenced base of school location (DANE)

Table: Descriptive statistics

Variable	Treated		Control		Difference
	N	Mean	N	Mean	
FEMALE DROPOUT 2Y	5328	0.09 (0.15)	3398	0.1 (0.16)	-0.005 (-0.009)
MALE DROPOUT 2Y	5328	0.11 (0.16)	3398	0.12 (0.18)	-0.011 (-0.017)
DROPOUT RATE 2Y	5328	0.34 (0.36)	3398	0.36 (0.36)	-0.016 (0.006)
FEMALE DROPOUT RATE	5328	0.06 (0.14)	3398	0.07 (0.14)	-0.005 (-0.007)
MALE DROPOUT RATE	5328	0.07 (0.13)	3398	0.07 (0.14)	-0.006 (-0.008)
DROPOUT RATE	5328	0.22 (0.31)	3398	0.23 (0.31)	-0.014 (0.006)
MEDIUM ECONOMIC LEVEL	5328	0.04 (0.14)	3398	0.02 (0.08)	0.024 (0.052)
LOW ECONOMIC LEVEL	5328	0.85 (0.25)	3398	0.9 (0.2)	-0.044 (0.046)
FRAC SUBSIDIZED	5328	0.52 (0.2)	3398	0.52 (0.21)	-0.004 (-0.011)
FRAC REPEATERS	5328	0.52 (0.2)	3398	0.52 (0.21)	-0.004 (-0.011)
FRAC NEW STUDENTS	5328	0.52 (0.2)	3398	0.52 (0.21)	-0.004 (-0.011)
FRAC MALE	5328	0.52 (0.2)	3398	0.52 (0.21)	-0.004 (-0.011)
FRAC FEMALE	5328	0.48 (0.2)	3398	0.48 (0.21)	0.004 (-0.011)

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Conclusions

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

return to the summary!

- 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., 2012)
- Students from different race and income groups respond differentially to aid packages in their application and enrollment decisions depending on their levels of aid expectations. (Kim et al., 2009)

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

return to the Summary!

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?

return to the summary!

- 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 groundwaters, and ecosystems, which may impact academic performance.
- Perry 2012:

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

return to the summary!

- 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 (0.23)	0.006 (-0.009)