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

Jaime Polanco-Jiménez and Christian Posso *

June 15, 2025

Abstract

This study investigates the impact of the shocks in expected income resulting from the announcement of a hydrocarbon exploration on dropout rates in schools within the exploration areas of Colombia. Employing a Geographic Regression Discontinuity Design, we capture the local impact of exploration announcements and establish a causal relationship. Our findings reveal a significant reduction in dropout rates among elementary school pupils, with a more pronounced effect observed among girls. However, an increase in dropout rates is observed among secondary school pupils. These results highlight the complex and nuanced relationship between natural resources and educational outcomes, suggesting the presence of underlying factors influencing dropout rates at different stages of schooling. These findings underscore the critical importance of incorporating the impact of expected income shocks in educational policy formulation, particularly within the exploration and exploitation of natural resource areas.

JEL Codes: Q32 ,I21.
Key Words: oil and gas exploration, education, human capital accumulation, labor force,

*Polanco: PhD student at KU Leuven & Pontificia Universidad Javeriana, (email: jaime.polanco@javeriana.edu.co); Posso: Banco de la Republica de Colombia (email: cpossosu@banrep.gov.co). We thank XXXXX, and XXXX for excellent research assistance. We thank to Brigitte Castaneda, Luz Abadia and Omar Garzon and seminar participants at XXXX and XXXX for insightful comments. The findings, interpretations, and conclusions expressed in this paper do not necessarily reflect the views of Banco de la República or its Board of Directors.

1 Introduction

The called "resource curse" is important for the aggregate economy, in particular to the economic growth (Brunnschweiler, 2008; Frederick, 2011; Quintero Otero, 2020; Sala-i Martin & Subramanian, 2012).[1] There is evidence that 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). This paper studies how Colombia's hydrocarbon policy affects school performance in primary and secondary education.

This paper aims to provide new evidence on the impact of hydrocarbon exploration on dropout rates (and academic performance in the future). Colombia has substantial dependence on hydrocarbon resources, which constitute a significant portion of its export earnings and government revenues, highlighting the need to comprehensively examine the consequences of oil price fluctuations and demand shocks on the educational sector.

Our paper is an improvement with respect to the previous literature on this topic in four ways. First, previous literature on this topic relies on cross-country data or country-level panel data, or they are limited just to the grades of schools. In this paper, we use granular, individual-school-level panel data on enrollment and dropout rates from Colombia's [2], covering all grades in elementary and secondary school. In addition, for this project, we create a georeferenced base of school locations for the whole country [3] that includes the latitude and longitude for each school.

Second, the key empirical contribution in this paper is that we combine the educational data with contract data from Colombia's National Hydrocarbons Agency from 2012 to 2020. In Colombia, the National Hydrocarbons Agency (ANH) plays a pivotal role in regulating the oil and gas industry. The ANH issues exploration and production contracts, collects royalties and taxes, and oversees the operations of oil and gas companies. Understanding the legal framework and contractual agreements between the ANH and the industry is crucial for evaluating the impact of hydrocarbon exploration on educational outcomes.

The Exploration and Production contract (E&P) serves as the primary legal instrument governing the relationship between the ANH and oil and gas companies. This contract outlines the rights and obligations of both parties and sets the terms and conditions for oil and gas production in Colombia. The Preliminary Phase of an E&P contract is of particular interest in this study. This phase, also referred to as the hydrocarbon exploration announcement typically lasts up to 24 months. During this period, the E&P company undertakes various activities, such as confirming the presence or absence of communities in the area, conducting consultations, obtaining environmental authorizations, and allocating resources for exploration work.

By focusing on the hydrocarbon exploration announcement, we aim to examine its

[1] Sala-i Martin and Subramanian (2012) refers the natural resource curse to the paradox that countries abundant in natural resources like oil and minerals tend to have less economic growth and worse development outcomes than countries with fewer natural resources.

[2] SIMAT database from 2012-2020

[3] from the National Administrative Department of Statistics (DANE)

specific impact on surrounding communities, including the anticipated income changes and subsequent decision-making among students, and their families, attending schools located in the exploration area. The announcement of hydrocarbon exploration has the potential to generate significant shifts in economic prospects and income expectations, which can influence the educational choices and aspirations of students. Understanding the implications of this announcement on the decision-making process of students is crucial for policymakers, educators, and researchers seeking to develop targeted interventions and strategies that support educational development in resource-dependent regions. With over 300 E&P contracts in Colombia (Administrative Department of National Planning (2021)), our study focuses on the areas impacted by hydrocarbon exploration under these contracts. These areas by 2020 had impacted more than 731,000 students in 2,450 schools located in 165 municipalities with low unrestricted income and low population density.

Third, we exploit a quasi-experimental variation associated with the policy of hydrocarbon exploration in Colombia. Previous literature focuses on cross-sectional regressions, panel regressions, or instrumental variable approaches. We apply a Geographic Regression Discontinuity Design (GRD) to compare schools inside vs outside exploration contract boundaries (Keele & Titiunik, 2015). We specifically examine the dropout rate within schools located in the designated intervention area where hydrocarbon exploration announcements have been made. Within our study, the educational institutions that fall within the specific boundaries of an Exploration and Production (E&P) contract are considered as the treated group. Conversely, the control group comprises educational institutions located in close proximity to the border of the delimited exploration area specified in an E&P contract. It is important to note that the delineation of the exploration area specified in an E&P contract is not related to the level of education in the area but rather determined by geological considerations.

By analyzing this relationship, we aim to shed light on the potential consequences of such announcements on educational outcomes in affected areas. This design enables us to identify the causal impact of hydrocarbon exploration announcements on dropout rates and academic performance. Relatively to previous literature, the GRD provides stronger internal validity by exploiting geographic discontinuity. Our research contributes to the existing academic literature on the natural resource curse by uncovering the link between hydrocarbon exploration announcements, dropout rates, and educational outcomes.

Fourth, in this paper, we provide a conceptual framework grounded in economic theory to model how exploration announcements affect incentives and decisions of students and families through income expectations. A fundamental aspect of our framework is that we explore the trade-off between changing expectations among children (and their families) in and out of working age. Previous literature has less formal theoretical backing for the mechanisms linking resources and education (this section is in process).

Our research aims to explore the relationship between hydrocarbon activities and educational outcomes. We investigate how hydrocarbon exploration announcements in Colombia affect the dropout rate, which refers to the proportion of students who discontinue their education (Colombian Ministry of Education (2009)). The dropout rate is a crucial indicator of overall school performance, as highlighted by R. W. Rumberger and Thomas (2000). Within our study, we specifically examine the dropout rate within schools located in the designated intervention area where hydrocarbon exploration announcements have been made. By analyzing this relationship, we aim to shed light on the potential consequences of such announcements on educational outcomes in affected areas.

Our main result is the following. The study reveals a significant reduction in dropout rates among elementary school students following exploration announcements, with the effect being more pronounced among girls. However, a contrasting increase in dropout rates is observed among secondary school pupils. The analysis estimates the average treatment effect on dropout rates to be -5.828 percentage points for elementary schools, with a larger impact seen in fifth grade students. For secondary schools, the average treatment effect on dropout rates is estimated to be 9.6 percentage points, with the greatest increases occurring in the final years of schooling.

Our research contributes to the existing academic literature by uncovering the link between hydrocarbon exploration announcements, dropout rates, and educational outcomes. Existing literature provides evidence of the relationship between income expectations and educational achievement, highlighting the importance of considering income shocks and their consequences when examining the relationship between economic activities and education outcomes. Studies such as Brueckner and Gradstein (2016), Michael Bernard Coelli (2005), M. Björkman (2013), Pablo A. Peña (2013), Michelmore (2013), Cerutti, Crivellaro, Reyes, and Sousa (2019), and Belley and Lochner (2007) have explored various aspects of this relationship. They have found that a negative shock on expected earnings is related to an increase in student dropouts, with girls being more affected than boys. These findings emphasize the significance of understanding the differential impacts of income shocks on different student populations, as well as the need for targeted interventions to mitigate the negative consequences and support educational attainment in resource-dependent regions.

For example, Dahl and Lochner (2017) finds that a $1,000 increase in family income raises combined math and reading test scores by 6% of a standard deviation in the short-run. Similarly, Chevalier and Lanot (2002) finds that children from poorer families are less likely to invest in education, but a financial transfer would not lead to a significant increase in schooling investment, which supports the view that family characteristic effects dominate the financial constraint effects. Additionally, Checchi (2004) shows that income inequality is negatively related to per capita income and positively related to capital/output ratio and government expenditure in education. However, Checchi (2004) also finds that the relationship between income inequality and average years of schooling is U-shaped, with a lower turning point at 6.5 years. Other studies, including those conducted by Michelmore (2013), Belley and Lochner (2007), and Davis-Kean (2005), have investigated the impact of income shocks on educational outcomes in various contexts. Collectively, these studies provide compelling evidence that increasing household incomes can effectively reduce dropout rates, particularly among impoverished households and marginalized ethnic minority groups.

The remainder of this article is organized as follows. In Section 2, we present the institutional context surrounding Oil and Gas exploration and production concessions in Colombia. Our conceptual framework and the mechanisms by which a hydrocarbon field can affect education are discussed in Section 3. The data used in this study are described in Section 4, and the results are presented in Section 6. Finally, in Section 7, we draw our conclusions. Additional tests and results can be found in the appendix.

2 Institutional context

The presence of petroleum in Colombian territory dates back to 1536, marking its early discovery. However, it was not until the early 20th century that formal regulations and concessions were introduced, establishing the framework for the subsequent growth of the petroleum industry in Colombia.

During the 1900s, Colombia's oil industry experienced significant development through the implementation of regulatory measures and the granting of concessions to private companies, laying the foundation for future industry growth (Agencia Nacional de Hidrocarburos (ANH) (2012)).

From 1924 to 2000, the oil industry in Colombia witnessed substantial growth and development. This growth was driven by key factors such as the enactment of the Petroleum Law in 1931, the establishment of ECOPETROL (the Colombian Oil and Gas Company) in 1951, the promulgation of Law 20 in 1969, and the discoveries of the Caño Limón and Cupiagua oilfields in 1983 and 1993, respectively.

In 2003, the hydrocarbon sector in Colombia entered a new phase with the establishment of the National Hydrocarbons Agency (ANH). The ANH was entrusted with the comprehensive administration of the nation's hydrocarbon reserves, while balancing the interests of society, the state, and the companies operating in the sector.

The Exploration and Production contract (E&P) serves as the primary legal instrument governing the relationship between the ANH and oil and gas companies in Colombia. This contract grants exclusive rights to the contractor for exploring and producing conventional hydrocarbons within the contracted area. The E&P process encompasses various contractual stages, including the preliminary phase, exploratory stage, production stage, and abandonment stage (See figure A.1). A clear understanding of the characteristics and requirements associated with each stage is vital for ensuring efficient and effective operations in the hydrocarbon sector, benefiting both the ANH and the contracting companies.

To identify E&P areas with hydrocarbon potential, the ANH employs diverse techniques and methodologies that consider factors such as geological and mining characteristics of rocks, as well as the results of previous exploration efforts in similar geological strata. This systematic and comprehensive evaluation of geologic conditions aims to identify areas with a higher likelihood of containing hydrocarbons.

The preliminary phase represents the initial stage of the hydrocarbon exploration and production contract, which lasts up to 24 months and can be extended for consecutive terms of six months. During this phase, the contractor is obligated to fulfill specific obligations and activities with diligence and ordinary care. The ANH provides support to the contractor during this phase; however, it is important to note that such support does not create any obligations or liability on the part of the ANH.

The preliminary phase concludes under three circumstances: (i) it is determined that fulfilling the obligations and activities inherent to the preliminary phase is unnecessary, leading to the issuance of a certification by the ANH to that effect; (ii) the duration of the preliminary phase expires without meeting the specified conditions; or (iii) the contractor provides evidence of fulfilling the obligations and activities inherent to the preliminary phase, and the ANH certifies their compliance. In cases where the preliminary phase terminates due to the contractor's imprudence or negligence, the contractor is obligated to reimburse the entire investment corresponding to the development of activities in the exploratory program of phase 1.

Following the preliminary phase, the exploratory stage assumes a crucial role in hydrocarbon exploration and production contracts. This stage involves a series of exploratory activities conducted by the contractor to identify and assess the hydrocarbon potential within a designated area. The duration of the exploratory stage, which depends on the area's characteristics and the type of hydrocarbons being sought, is specified in the contract.

Within the exploratory stage, the contractor is responsible for executing an Exploratory Program that encompasses various technical exploration activities, such as seismic acquisition and drilling wells, as outlined in the contract. Additionally, the contractor must submit an exploration plan to the competent authority, detailing the proposed implementation of the exploratory activities along with the budget required for executing the Exploratory Program. Throughout this stage, the contractor must carry out all planned exploration activities according to the phases stipulated in the contract. If the contractor intends to conduct additional or complementary exploratory operations beyond those outlined in the Exploratory Program, they must provide written notification to the competent authority. Furthermore, the contractor may request an extension for any of the phases within the exploratory stage, subject to specific requirements specified in the contract.

Upon completion of the exploratory stage, provided there is at least one area under evaluation, one area in production, or a duly reported discovery to the competent authority, the contractor has the option to retain or relinquish 50% of the assigned area (excluding areas under evaluation, in production, or associated with the discovery) for the purpose of conducting a subsequent exploratory program. To initiate this program, the contractor must notify the ANH in writing at least three (3) months before the termination date of the last phase of the exploratory stage. The notice must express the contractor's interest in undertaking the subsequent exploratory program and include a detailed budget and schedule of all exploration operations and activities to be carried out in the program, starting from the completion of the last phase of the Exploratory Program.

Moving into the production stage, this phase represents the period during which hydrocarbon production operations take place within the assigned area. The production stage commences after the completion of infrastructure development and lasts for a duration of thirty years. It is essential to note that the production stage applies to each specific area assigned for production, meaning that any references to its duration, extension, or termination pertain to each individual assigned area.

Throughout the production stage, the contractor is obligated to provide the ANH with a monthly production forecast for each assigned area within the corresponding calendar year, an average annual production forecast until the economic life of the reservoirs within the respective assigned area is reached, and an estimation of expenditures, expenses, and investments for the next four calendar years or until the completion of the production stage, whichever is shorter. Development and production operations are mandatory and must commence as per the submitted schedule.

Moving to the abandonment stage, this phase entails the return of the assigned exploration or production areas by the contractor. During this stage, the contractor is required to prepare and present an Abandonment Program to the National Hydrocarbons Agency (ANH) for approval. The program should include a comprehensive schedule detailing the process of returning the assigned areas. Within the program, all wells, structures, immovable properties, machinery, and other movable assets to be removed must be classified and listed, along with their corresponding values determined based on the criteria defined in Clause 21.1.7.

Once the ANH approves the Abandonment Program, the contractor must initiate and carry out the abandonment procedure in accordance with the contractual requirements to the satisfaction of the ANH and other relevant authorities. It is crucial to note that the abandonment procedure cannot be interrupted without sufficient justification and prior written notice to the ANH. In summary, the Abandonment Stage signifies the period in which the contractor is responsible for returning the assigned exploration or production areas, following an approved program by the ANH and adhering to the contractual obligations.

The stages of exploration and production contracts within the hydrocarbon sector of Colombia play a vital role in governing the relationship between the ANH and oil and gas companies. Understanding the characteristics, obligations, and timelines associated with each stage is essential for ensuring successful operations and promoting the sustainable development of the hydrocarbon industry in Colombia. By adhering to these stages and fulfilling their responsibilities, both the ANH and the contracting companies contribute to the effective and efficient management of the sector, leading to long-term growth and environmental sustainability.

However, it is crucial to recognize that achieving successful outcomes in the hydrocarbon sector goes beyond contractual obligations. Social factors also hold significant importance in shaping the overall project impact. Unfortunately, the education and awareness of individuals residing within the exploration areas often receive insufficient attention, hindering the effective fulfillment of contractual activities. Neglecting the social dimension undermines the potential benefits that can be derived from community engagement and participation.

The Colombian education system comprises various levels, including early childhood education, preschool education, basic education (consisting of five years of primary education and four years of secondary education), upper-secondary education (two years culminating in the attainment of the high school diploma), and higher education. For the purpose of this study, we specifically focus on elementary education (five grades of primary education), secondary education (four grades of secondary education), and two grades of upper-secondary education. This division allows for practical analysis and examination of the different stages within elementary and secondary education.

One critical aspect of fostering social integration is the process of socializing the project with local communities, which plays a pivotal role in generating future income expectations among the inhabitants. It is through effective socialization efforts that change in behavior and attitudes can be motivated, creating a more collaborative and supportive environment for the project as a whole. Recognizing the significance of education in this context, this paper aims to delve into a comprehensive evaluation of the behavioral changes exhibited by students studying in schools situated within the intervention zones. By examining the impact of education on community engagement and participation, this research seeks to shed light on the transformative potential of empowering individuals through knowledge and fostering sustainable development in the hydrocarbon industry.

While adherence to contractual obligations and stages is crucial, integrating social factors, particularly education, is equally essential for achieving successful outcomes and promoting sustainable development. By bridging the gap between contractual activities and community engagement, we can harness the transformative power of education and empower individuals to actively participate in the hydrocarbon industry's development. Through this research, we aim to contribute to the broader understanding of the interplay between education, behavior change, and sustainable practices in the context of hydrocarbon exploration and production in Colombia.

3 Conceptual framework (under construction)

[in the next round of the draft expect to have a more formal model that differentiates the effects between kids in and out of working age (elementary vs secondary school)]

The objective of this study is to investigate the impact of income shocks on dropout rates in schools within exploration areas in Colombia. With the expansion of hydrocarbon exploration activities in various regions of the country, local communities experience significant changes in their economic conditions, particularly through the announcement of hydrocarbon exploration projects. These announcements often generate expectations of increased income and economic opportunities among the inhabitants. However, the effects of such income shocks on social outcomes, particularly in the realm of education, remain relatively unexplored.

In this section, we are detailing the mechanism by which students are affected, and we are explaining how the effect of exploration announcements is heterogeneous by gender and by grade level. We are also discussing in detail the empirical strategy (See 5.1) that enables us to establish the causality of the announcement of oil exploration on the dropout rate in Colombia.

The Colombian Ministry of Education (2009) considers that a student has dropped out when he/she does not continue his/her educational path and does not enroll in a school. This inter-annual definition of dropout is based on the comparison between students enrolled at the beginning of the educational period and those who do not enroll in any educational center in the following year. The equation 1 represents the count of students who discontinued their education and dropped out of school (denoted as s) during the next time period (denoted as $t+1$). represents the calculation of the dropout rate for a specific school during a particular time period.

$$Dropout_{s,t} = \frac{\text{Students who dropped out}_{s,t+1}}{\text{Enrolled Students}_{s,t}} \quad (1)$$

The announcement of oil exploration within a region generates a significant positive shock in the expected income of families residing in the exploration zones. As supported by previous studies (Brueckner and Gradstein (2016), Michael Bernard Coelli (2005), Cerutti et al. (2019), and Belley and Lochner (2007)). Specifically, an increase in the expected income of families with children studying in the intervention areas corresponds to a decrease in the rate of student dropout. In simpler terms, when the anticipated income of families within these areas rises, the likelihood of their children dropping out of school decreases.

It is important to mention that this effect is not homogeneous across educational levels. Authors as Stearns and Glennie (2006), Gibbs and Heaton (2014), Gibbs and Heaton (2014) describe, the effects of shocks of expected income on dropout rate are heterogeneous by educational level, age, and by gender. In elementary school, students have a strong dependence on family characteristics, which means that if the family has a shock in expected income, this family adjusts its behavior, including the future value of the education they perceive for their children. In high school at ages between 10 and 15[4], students can already enter the labor force, which implies that these students can also provide for family income. In this case, a shock in expected income is borne directly by the student and not just through his or her family.

In this study, we explore the relationship between study time and family characteristics, along with students' attributes, in response to expected family income shocks. The study time (S) refers to the amount of time students spend studying, and it is inversely related to the dropout rate. For a more detailed and comprehensive explanation of the mathematical model and equations, interested readers can refer to the section 3.1

3.1 Theoretical model

Family characteristics are influenced by factors such as parents' education, the income of the student's family, and the level of parental involvement in the student's education. For elementary school students, students are not typically contributing financially to their families. However, for secondary school students, their personal attributes can impact family income, making them relevant in this context. Personal characteristics (St) include intelligence (I_S), motivation (M_S), and study habits (H_S), and we observed a stronger relationship between personal characteristics and family income for elementary students compared to secondary students.

To understand the impact of expected family income shocks, we examine how study time responds for both elementary and secondary students. For elementary students, an increase in family income positively influences study time, leading to more time dedicated to studying. In contrast, for secondary students, the relationship is more complex. An increase in family income affects both family characteristics and personal characteristics. Here, we observe a trade-off as students may prioritize contributing to family income over dedicating time to studying, potentially leading to a decrease in study time.

In equation 2, we define that the dropout rate is inversely proportional to time spent studying S, and time spent studying is a function of students' family characteristics (F) and students' personal characteristics (St). As Gibbs and Heaton (2014) describe, family characteristics are an approximation of the student's family income. This is a function of the parents' education (E_P), the income of the student's family (I_F), and the parent's involvement in the student's education (Inv_P). In elementary school, we could assume that family income is not related student's personal characteristics (Pupils can not obtain income for supporting the family incomes), this assumption is not the same for students of secondary school, due to students in secondary school might

[4]In Colombia, the working age population is defined from 15 years of age onwards for the entire national territory. This measurement is in effect as of January 2021 when the National Administrative Department of Statistics (DANE) implemented methodological changes in the measurement of the working-age population to bring it in line with international comparisons (Convention 138 of 1973 of the International Labor Organization (ILO) on the minimum working age). The historical series with back projections of the 2018 National Population and Housing Census consider this same age range. The historical series without back projections of the 2018 Census (series based on the 2005 Census) considered the working-age population as from 12 years of age in urban areas or municipal capitals and from 10 years of age in rural areas or rest zone.

contribute to incomes of the family. On the other hand, as is mentioned by Steinmayr, Weidinger, Schwinger, and Spinath (2019) and Harris (2010), 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 students' personal characteristics (St) in elementary school are related to the income of the student's family (I_F) strongly, and in secondary school this relation is weaker($\alpha_{sec} >>> \alpha_{elem}$).

$$S = g(F, St) + \eta \tag{2}$$

Thus, we can define the function of student family characteristics in terms of $IF = F = h(E_P, I_P, Inv_P, St) + \nu$, where $St = 0$ for elementary school students (elementary school students' characteristics do not contribute to family income), for secondary school students students' personal characteristics, could contribute to family income (i.e. $St \geq 0$). Likewise, we can define the function of student characteristics in terms of $St = j(I_S, M_S, H_S, H_S, \alpha I_F) + \mu$. By replacing these definitions in equation 2, we obtain the equation 3:

$$S = g(h(E_P, I_F, Inv_P, St), j(I_S, M_S, H_S, H_S, \alpha I_F)) + \eta \tag{3}$$

To demonstrate the partial derivative of equation 3 with respect to the shock in expected family income ($E[I_F]$), we can differentiate the equation for both elementary school students and secondary school students.

For elementary school students, where $St = 0$, the equation simplifies to:

$$S_{\text{elem}} = g(h(E_P, I_F, Inv_P)) + \eta_{\text{elem}} \tag{4}$$

Taking the partial derivative of equation 4 with respect to $E[I_F]$ yields:

$$\frac{\partial S_{\text{elem}}}{\partial E[I_F]} = \frac{\partial g(h(E_P, I_F, Inv_P))}{\partial E[I_F]} > 0 \tag{5}$$

In this case, an increase in $E[I_F]$ will lead to an increase in S_{elem}, assuming all other family characteristics and student characteristics remain constant. This implies that the family's higher expected income positively affects the time spent studying by elementary school students.

Now, let's consider secondary school students. The equation for them is:

$$S_{\text{sec}} = g(h(E_P, I_F, Inv_P, St), j(I_S, M_S, H_S, H_S, \alpha I_F)) + \eta_{\text{sec}} \tag{6}$$

To find the partial derivative of equation 6 with respect to $E[I_F]$, we differentiate it as follows:

$$\frac{\partial S_{\text{sec}}}{\partial E[I_F]} = \frac{\partial g(h(E_P, I_F, Inv_P, St), j(I_S, M_S, H_S, H_S, \alpha I_F))}{\partial E[I_F]} \tag{7}$$

In this case, the impact of the shock in expected family income ($E[I_F]$) is not isolated as it affects both the family characteristics (F) and the personal characteristics of the student (St). The equation captures the trade-off between contributing to family income and allocating time to studying. As secondary school students may prioritize work or other activities to support the family, an increase in $E[I_F]$ might lead to a decrease in study time (S_{sec}).

4 Data

This study utilizes a combination of three primary datasets to investigate the impact of hydrocarbon exploration announcements on school dropout rates in Colombia. The analysis relies on the Student Enrollment System in Colombia (SIMAT) data, covering the period from 2012 to 2020. This dataset offers valuable insights into student enrollment trends and characteristics, particularly for schools located near areas undergoing exploration and production (E&P) activities. Additionally, the integration of the E&P contracts in Colombia dataset, obtained from the National Hydrocarbons Agency (ANH), enables the examination of the relationship between contract signing dates and dropout rates during the preliminary phase. Furthermore, the georeferenced base of school locations provided by the National Administrative Department of Statistics (DANE) allows for spatial analysis and the investigation of the spatial distribution of schools in relation to E&P contract areas.

The comprehensive database employed in this study comprises an extensive range of essential information for understanding various aspects of the educational landscape. Notably, it provides insights into school dropout rates, gender distribution, and the total number of students. Additionally, it offers a comprehensive overview of enrollment status within the same school and sheds light on migration and immigration patterns. The inclusion of demographic data, such as socioeconomic stratum, age, subsidy type, and geographic details related to school campuses, further enriches the dataset. (See dictionary of the data based B.1)

Moreover, the database incorporates information associated with school, E&P contracts, and their operators, providing insight into contractual arrangements and the entities responsible for school administration. Supplementary columns with fractional values contribute to a more nuanced understanding of gender dynamics, socioeconomic stratum representation, age distribution, and other attributes. Geographical information, including coordinates such as longitude and latitude, as well as elevation, is captured in the dataset, facilitating a comprehensive exploration of the interplay between various factors within the educational landscape. Together, this diverse information fosters a deeper understanding of school dynamics and contextual influences, facilitating a more comprehensive academic exploration of the subject matter. The statistical description of the data can be seen in table B.2.

4.1 Schools

In our study, we included a total of 1625 schools, located in 108 municipalities of 18 departments of Colombia. We selected them based on their proximity to a border defined in an E&P contract. Specifically, we focused on schools located at a Euclidean distance[5] of less than 8500 meters from the contract-defined border. It is important to clarify that there are schools that teach both elementary and secondary school. Out of these 1625 schools, we found that 762 schools were situated outside the area covered

[5] In this study, we refer to Euclidean distance, which is a measure of the straight-line distance between a school and the border of the area under an E&P contract. It is calculated using the Pythagorean theorem, where the Euclidean distance between two points $P1(longitude_1, latitude_1)$ and $P2(longitude_2, latitude_2)$ is given by the formula:

$$\text{distance} = \sqrt{(longitude_2 - longitude_1)^2 + (latitude_2 - latitude_1)^2}$$

by the E&P contract (control group), while the remaining 863 schools were within the contracted area (treated group).

When we examined the control sample, which consisted of 762 schools, we discovered that the majority of these schools were dedicated to teaching elementary students (526 schools). Additionally, within this control sample, we identified 34 schools that provided education for secondary school students and 202 schools that teach all grades of elementary and secondary school. Out of the 728 schools teaching elementary students, we observed that 424 schools had more than 10 students per grade. Similarly, among the 236 schools teaching secondary school students, we found that a total of 220 schools had more than 10 students per grade.

In the treatment sample, which comprised 863 schools, we observed a similar distribution to the control sample. The majority of these schools (609) focused on teaching elementary students, while 46 schools were dedicated to secondary education, and 208 provided education for all grades of elementary and secondary school. Within the 817 schools teaching elementary students, we noticed that 528 schools had more than 10 students per grade. Among the 254 schools offering education for secondary school students, we found that 246 schools had more than 10 students per grade.

4.2 Student Caracteristics

In Colombia, the socioeconomic classification system is widely used to categorize households based on their living conditions and economic resources. This classification consists of six strata that approximate the hierarchical socioeconomic differences within the national territory. Stratum 1 represents the lowest socioeconomic class, while Stratum 6 represents the highest socioeconomic class associated with greater financial comfort, which is often interpreted as an indication of wealth.

Among these strata, Strata 1, 2, and 3 are classified as lower strata, comprising households with limited resources. Residents in these strata are eligible for subsidies in basic public utility services. On the other hand, Strata 5 and 6 are considered higher strata, housing households with greater economic resources. Residents in these strata are subject to additional costs (contributions) on top of the regular charges for public utility services. Stratum 4, however, does not receive subsidies nor incur additional costs, but rather pays the exact amount determined by the service provider as the service provision cost.

In the context of this study, it is important to note that 8% of the students did not provide information about their socioeconomic stratum. Among the remaining 92% who reported their stratum, it was found that 75% of the students belong to socioeconomic Stratum 1, which is associated with the lowest levels of poverty. Stratum 2 accounted for 14% of the students. Strata 3 and 4, representing the middle socioeconomic stratum, showed a lower representation, accounting for 3% of the students in this study. Notably, the highest socioeconomic strata, namely Strata 5 and 6, exhibited the lowest representation, with less than 0.03% of students falling into these categories.

A comprehensive overview of student characteristics, encompassing both treated and control groups, is presented in Table X. The analysis reveals that students attend-

In our case, we use the Euclidean distance to determine the proximity of schools to a specific border defined in a contract of exploration and production. A Euclidean distance of less than 8500 meters indicates that a school is located within the specified range of the border.

ing schools in proximity to the boundary of the exploration and production contract area exhibit remarkably similar traits. These similarities are evident in the distribution of male and female students within each class, as well as in their socioeconomic backgrounds, which show no discernible differences based on socioeconomic stratum attributes.

4.3 Areas under an E&P Contract

The present study evaluated the average radius of oil and gas exploration and production areas. We considered a sample of 180 areas for analysis that corresponds to onshore E&P contracts signed from 2003 until 2019[6]. Our findings revealed that the average minimum distance from the centroid to the border of these areas was approximately 4023 meters[7], accompanied by a standard deviation of 4002 meters. Consequently, we can infer that, on average, the areas extend significantly from their centroid to the closest boundary. It is notable that the variable exhibited a wide range of variability, with the recorded minimum distance being 1003 meters and the maximum distance reaching 27829 meters.

Further analysis of the distribution's percentiles revealed that 25% of the areas demonstrated a minimum distance from the centroid to the border of 1561 meters or less. Moreover, the median (50th percentile) indicated that half of the areas had a minimum distance of 3088 meters or less. Additionally, 75% of the areas exhibited a minimum distance of 6649 meters or less. These outcomes suggest that oil and gas exploration and production areas encompass diverse sizes and shapes, resulting in varying levels of extension from the centroid to the border. It is noteworthy to mention that outliers or extreme values within the distribution may influence the observed variability concerning the minimum distance.

All signed contracts are distributed according to sedimentary basins across the entire territory of Colombia, including offshore areas. However, when estimating the effect of E&P (Exploration and Production) announcements on education, we exclude offshore areas from consideration. With the intention of maintaining homogeneity at all treatment edges, we further excluded areas that lie in two or more sedimentary basins. This allows us to estimate that all treated schools are located in areas with identical mining geological conditions.

As shown in Figure 1, all areas are distributed based on their corresponding sedimentary basins, and even no area coincides with the sedimentary basins with other geographical or administrative regions, such as municipalities. This exclusion ensures that the treatment areas are isolated within a single sedimentary basin, enhancing the comparability and validity of the estimates in our analysis.

[6] We restrict the study to contracts signed before the year 2020, due to the heterogeneities that could be produced by the COVID-19 pandemic. The pandemic forced students to carry out their academic activities from home, which changes the conditions and school interaction. student.

[7] This measure refers to the Euclidean distance between the geometric center of the areas under E&P contract and the geometric edge of the nearest area. It specifically captures the minimum distance from the centroid to the edge, providing a meaningful representation of the spatial extension of these areas.

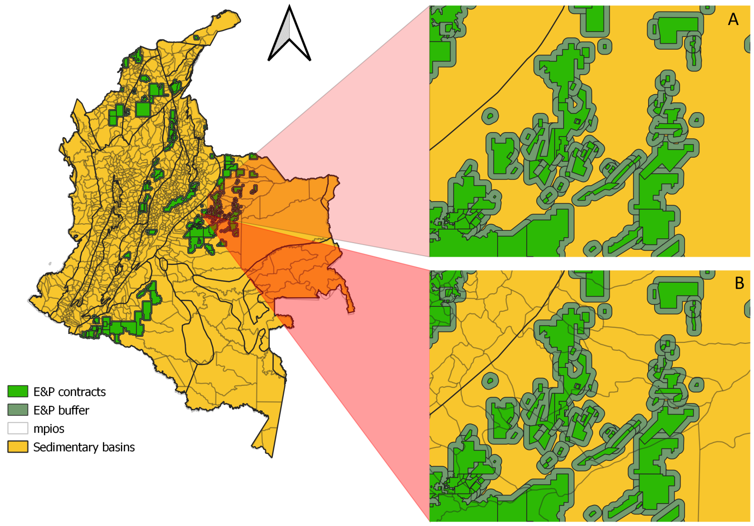


Figure 1: Map of exploration and production contracts located in the different sedimentary basins of the country and their distribution regarding the municipalities

The mean size of the contract areas is approximately 420.33 square kilometers, with a standard deviation of approximately 615.99 square kilometers. The minimum contract area is 5.56 square kilometers, while the maximum contract area is 3134.15 square kilometers. The distribution of contract areas shows a significant variation, with 25% of the contracts having areas smaller than 23.59 square kilometers, 50% having areas smaller than 173.66 square kilometers, and 75% having areas smaller than 480.67 square kilometers. The contract areas exhibit a wide range of sizes, reflecting the diversity and heterogeneity of the E&P operations in Colombia.

5 Empirical Strategy

The delimitation of exploration areas is based on the mining and geological characteristics of the area, and these are not related to the educational characteristics of the area. Therefore, in this study, we evaluate the effect of being within the area where hydrocarbon exploration is announced and compare it with the dropout of schools located in areas close to the boundary of the exploration area.

In order to identify the causal effect of hydrocarbon exploration announcements on dropout rates and academic performance of students in the exploration areas of Colombia, we employ a Geographic Regression Discontinuity Design (GRD) to capture the local impact of exploration announcements and establish a causal relationship between income shocks and dropout rates. By leveraging geographical boundaries and exploiting the temporal variation in exploration announcements, we aim to provide robust evidence on the effects of income shocks resulting from hydrocarbon exploration announcements on dropout rates in schools situated within the exploration areas of Colombia.

Furthermore, we investigate potential heterogeneities in the treatment effect by considering student characteristics such as grade and gender. By examining variations in the effect of hydrocarbon exploration announcements across different grade levels and between male and female students, we can gain insights into the differential impact of these announcements on dropout rates. These heterogeneities help us understand how the treatment effect may vary among different student subgroups and provide a more comprehensive analysis of the educational outcomes associated with hydrocarbon exploration.

GRD is a type of natural experiment used by scientists to draw causal inferences with observational data (Keele & Titiunik, 2015). In this design, the borders of the geographic area are defined by the ANH based on underground mineral and geological conditions. In other words, the division into treated and control areas occurs in an as-if random fashion. This implies that the edge is not defined by the educational conditions of students in the exploration areas.

To estimate the causal effect of the hydrocarbon exploration announcement on the school dropout rate at time t ($Dropout_{s,t}$), in a simplified way we estimate it as presented in the equation 8 using the methodology proposed by Calonico, Cattaneo, and Farrell (2018, 2020); Calonico, Cattaneo, Farrell, and Titiunik (2017, 2019); Calonico, Cattaneo, and Titiunik (2014a, 2014b, 2015a, 2015b); Cattaneo, Frandsen, and Titiunik (2015); Keele and Titiunik (2015). X_i is the running variable defined by the perpendicular distance of the school s to the border of the area on exploration. Our parameter of interest to be estimated is β_2, this parameter capture the effect of a hydrocarbon exploration announcement (HEA_t) on the number of students that was enrolled in time t but no continue with their studies in time $t+1$ as was referenced in the equation 1. Finally, ε_i is an error term.

$$Dropout_{s,t} = \alpha + \beta_1 \cdot X_s + \beta_2 \cdot HEA_t + \varepsilon_s \tag{8}$$

The design allows us to estimate geographically located treatment effects that can also be used to validate the identification assumptions using observable pretreatment characteristics. However, the continuity assumptions needed for identification hold less often when applied to geography. When discontinuities are geographic, agents may sort very precisely around the boundaries and undermine the validity of the design. To use geographic discontinuities to estimate treatment effects, we collected geographic data (area with latitude and longitude of each E&P Contract, latitude and longitude of each school) along with more traditional covariates.

The GRD design allows us to estimate treatment effects that are geographically located and account for compound treatments, the role of distance to the boundary, and geographic treatment heterogeneity. However, it is important to note that the continuity assumptions needed for identification may not hold as precisely in geographical contexts, as agents may sort around boundaries and undermine the validity of the design.

The relationship between the existence of oil reserves and the level of education is considered exogenous. The discovery of oil acts as a random treatment for individuals residing above the newly found oilfield. In this context, the Hydrocarbon Exploration Announcements (HEA) introduce a change in expectations regarding future incomes. It is worth noting that the treatment boundary is not determined by the dropout rate of the area but rather by the occurrence of HEA.

Given that the potential outcomes are assumed to be random, the application of randomized experiments allows us to examine the expected difference in outcomes between schools that receive the HEA under an E&P contract (the treated group) and schools that do not receive the announcement (the control group), conditional on the occurrence of HEA. Under the above assumptions, equation 9 is the parameter we expect to identify, which measures the causal effect of the HEA on dropout rates:

$$\tau_{ATE} = \tau_{ATET} = E\left[D_s(1) - D_s(0)\right] = E\left[D_s(1) - D_s(0)|\text{HEA} = 1\right] \quad (9)$$

To verify the validity of our empirical strategy, we examine the assumptions proposed by Keele and Titiunik (2015), Cattaneo, Idrobo, and Titiunik (2020) and Abadie and Cattaneo (2018), which includes Conditional Local Geographic Treatment Ignorability, Compound Treatment Irrelevance, and Naive distance. These assumptions ensure that any differences in outcomes between the treated and control areas are solely attributable to the hydrocarbon exploration announcement and not influenced by other geographic factors.

5.1 Identification (under construction)

The first identify assumptions is the Conditional Local Geographic Treatment Ignorability. According with this assumption the potential outcomes of treatment are solely influenced by the treatment itself and are not affected by other geographic factors[8]. In our case, the treatment refers to the area that is contracted for exploration and production of hydrocarbons (E&P) during the preliminary phase. It is important to emphasize that the determination of the E&P contract area is based on mineral and geological conditions, rather than characteristics related to education in the area of interest. By comparing units on either side of the geographic boundary defined by the E&P contract area, we can estimate the treatment effect, assuming that any differences in outcomes are solely attributable to the treatment and not influenced by other geographic factors. This assumption ensures that the hydrocarbon exploration announcement, is the primary treatment that affects potential outcomes, while other simultaneous treatments are considered irrelevant in the context of the research design.

Second, the Naive distance is a measure of distance that does not account for the spatial nature of geographic locations. It simply represents the shortest distance between two points, disregarding any obstacles or boundaries that may exist in between. In the context of this study, it is assumed that the subsurface characteristics near the border of the contracted exploration area are identical. This assumption is supported by the fact that the schools, both treated and control, are located at an average distance of 4 km from the border. Additionally, the schools near the border belong to the same geologic basin and do not experience abrupt differences in geographic conditions. In other words, there are no significant geographic features, such as mountain breaks, that separate the treated and control schools. Thus, the random delimitation of the exploration area ensures that the schools in close proximity to the border share similar characteristics (see Figure 2). Taking this into consideration, calculating the minimum perpendicular Euclidean distance to the boundary is appropriate as it does not conceal important heterogeneities that may exist among the schools.

[8] The potential outcomes of school s is 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 $(Dropout_{s,1}, Dropout_{s,0} \perp\!\!\!\perp T_i | d_i < D)$

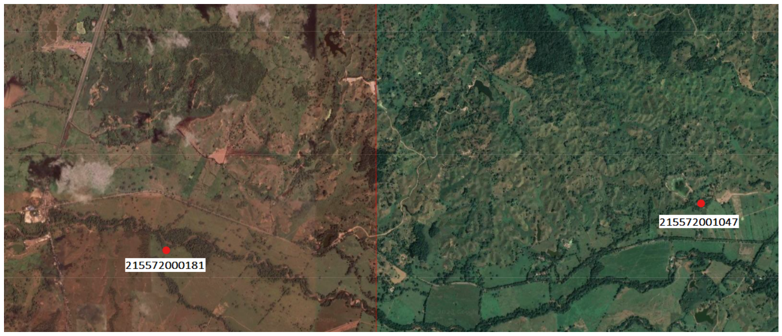


Figure 2: Real view of the geographical limit defined by an oil exploration and production contract.

To provide empirical evidence on the credibility of the continuity assumption needed for identification in the analysis of regression discontinuity (RD) designs, we carried out two falsification tests. In the first test, we explored the option of assuming a temporary placebo. The temporary placebo assumes a fictitious contract date, one year prior to the actual signing of the contract. In the short run, this artificial intervention should not make any difference in the dropout of students of schools close to the border of the area under an E&P contract. The second test that we evaluate in this study involves using covariates as an outcome, in this sense school characteristics and geographic characteristics are systematically identical on both sides of the border (i.e. conditions are identical in the treated and control areas).

To enhance the robustness and reliability of our findings, we conducted some additional analyses to verify the stability of the results and mitigate the influence of potential outliers or other factors. These robustness checks were performed to ensure that our conclusions are not contingent upon a particular method or assumption.

First, we carry out a bandwidth sensitivity test to determine the robustness of the results obtained from the regression discontinuity design to different bandwidth choices. To enhance the interpretability of our findings, we propose graphically plotting the estimated effects along with their corresponding confidence intervals. This visual representation allows us to assess the precision and uncertainty associated with the estimates derived from the Robust estimation method. By incorporating confidence intervals, we can ascertain the statistical significance of the estimated effects and provide a more comprehensive understanding of the treatment's impact on the outcomes of interest.

Second, we employed a density test to assess the continuity of potential outcomes at the cutoff in the context of each sampled school. The rationale behind this test is that if potential outcomes are continuous, the density of the outcome variable should be similar for both the treated and untreated groups at the cutoff point.[9] Subsequently, we performed a binomial test to examine whether the densities were statistically equivalent. To enhance the robustness of the analysis and account for potential deviations from continuity assumptions, we implemented the density test within a local randomization framework. This framework employed a bandwidth parameter and specified a

[9]To conduct the density tests, we utilized the rddensity command in R. This command allowed us to calculate the densities of the outcome variable around the cutoff separately for the treated and untreated groups.

confidence level for the binomial test, thereby ensuring more reliable results.Cattaneo et al. (2020)

In our research, we employ a placebo cutoff strategy to assess the validity of the treatment effect observed in the sharp regression discontinuity design. To do this, we select a placebo cutoff location that is sufficiently distant from the actual cutoff, such as 25 kilometers away. Utilizing the same regression discontinuity analysis techniques applied at the actual cutoff, we would examine the treatment effect estimate at the placebo cutoff. If this estimate is statistically significant, it implies that the observed treatment effect is not attributed to the specific design of the sharp regression discontinuity, but rather to other factors.

6 Results

This study examines the influence of expected income shocks resulting from the announcement of hydrocarbon exploration on dropout rates in schools located within the exploration areas of Colombia. The research question addressed in this study is to understand how the local impact of exploration announcements affects educational outcomes, specifically dropout rates, and to establish a causal relationship.

The main findings of the study reveal a significant reduction in dropout rates among elementary school pupils following exploration announcements. Interestingly, the effect is more pronounced among girls, indicating a potential gender-specific impact of expected income shocks on educational outcomes. However, a contrasting observation is made among secondary school pupils, with an increase in dropout rates observed.

To present the results more comprehensively, we divide the findings into two parts. Firstly, we focus on the impact on dropout rates in elementary schools, where a remarkable decrease is observed, suggesting the positive influence of the treatment intervention. Secondly, we focus on the results for secondary schools, where the increase in dropout rates raises intriguing questions and warrants further investigation.

These findings shed light on the complex and nuanced relationship between natural resource exploration and educational outcomes. The study highlights the presence of underlying factors that influence dropout rates at different stages of schooling, emphasizing the importance of considering the impact of expected income shocks in educational policy formulation, particularly in areas of exploration and explotation of natural resources. Understanding these dynamics can inform targeted interventions and policies to address the challenges faced by schools and students in resource-rich regions. The study's dual examination of elementary and secondary schools provides valuable insights for policymakers and educators to tailor strategies that address the specific needs of different educational stages within the broader context of economics and education science.

In our examination of elementary school data, as illustrated in Figure 3, the analysis reveals a compelling and statistically significant impact of the treatment on dropout rates. The average treatment effect (ATE) is estimated at -5.828 percentage points (pp), with a standard deviation of 1.6 percentage points. The decrease of 5,828 pp in relation to the behavior of the control schools (16.6%) allows us to infer a relative effect [10] of 35%.

[10] The ratio of the average treatment effect (ATE) of an intervention to the average outcome in the control

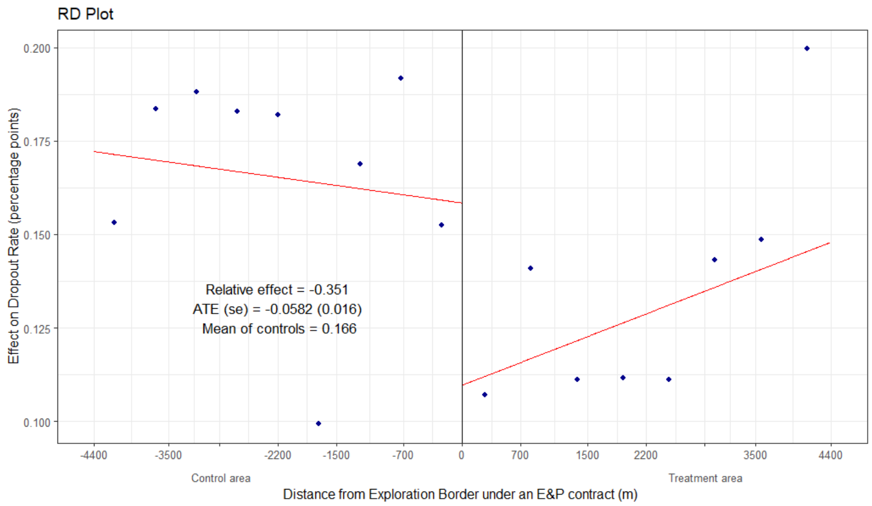


Figure 3: General Result in Elementary School: 1 year after treatment

The analysis of secondary schools reveals a more intricate picture. As shown in Figure 4, there is a notable rise in dropout rates among secondary school pupils following the exploration announcement. The estimated average treatment effect is 9.6 pp, with a standard deviation of 2.2 pp. This observation indicates a substantial and statistically significant increase in dropout rates among students at this educational stage. Specifically, the treatment significantly influences dropout rates for secondary school pupils, resulting in a 74% relative increase in the effect compared to the control group.

---

group, provides a measure of the impact of the treatment in relation to the baseline or control condition.
Mathematically, the relative effect (RE) is calculated as:

$$\text{Relative Effect (RE)} = \frac{\text{Average Treatment Effect (ATE)}}{\text{Average Control Outcome}}$$

Where:
Average Treatment Effect (ATE) is the difference in the outcomes between the treatment group and the control group, averaged over all participants in both groups. The **Average Control Outcome** is the average outcome observed in the control group.

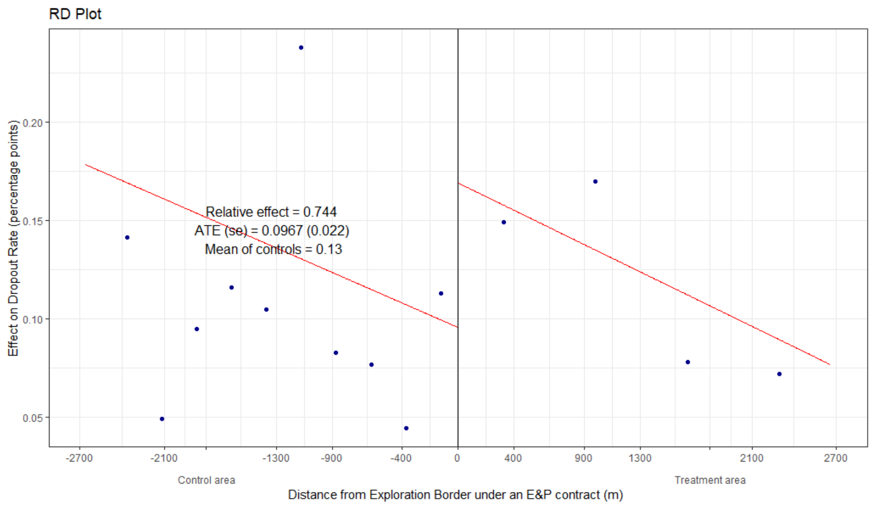
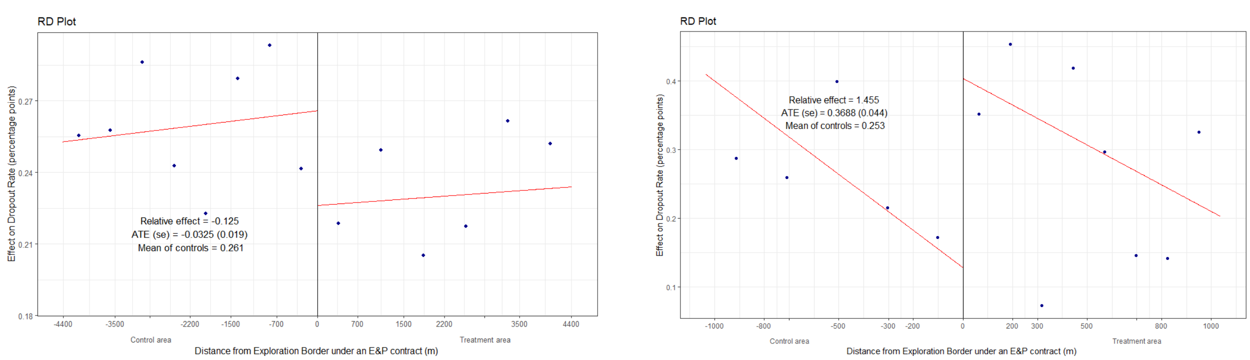


Figure 4: General Result in Secondary School: 1 year after treatment

After two years after the announcement of oil and gas exploration, the research reveals persistent effects on both elementary and secondary schools as shown the figure 5. In elementary schools, a remarkable positive outcome emerged, showcasing a significant decrease in school dropout rates by 3.25 percentage points in comparison to the control group's dropout rate (26.1 %). This reduction of 12.5 percentage points relative to the treatment group indicates that the announcement had a beneficial impact on students' engagement and retention in elementary education. However, the effects in secondary schools paint a different picture. The decision to drop out among secondary school students increased by 36.8 percentage points, contrasting with the control group's dropout rate of 25.3%. This alarming rise translates to a relative increase in the dropout decision by a staggering 145.5%. The exploration announcement evidently posed significant challenges to students' educational trajectories at the secondary level.



(a) Dropout rate 2 years after treatment in Elementary school

(b) Dropout rate 2 years after treatment in Secondary school

Figure 5: General Result: 2 years after treatment

6.1 Heterogeneities and robustness tests

In this section, we conduct a detailed analysis of the gender and grade heterogeneities of school products by exploring hydrocarbon announcements. Our findings suggest that gender and grade are important factors that influence the deception rates of school products.

Hydrocarbon exploration announcements have a different effect on school dropout depending on gender and educational level . In elementary schools, boys have a greater dropout rate than girls. Boys decreased dropout by 3.11 percentage points (with a standard deviation of 1 percentage point) with an effect relative to the control group of 69.5 percentage points (see figure 6). Girls, on the other hand, decreased school dropout by 0.84 percentage points with a standard deviation of 0.9 percentage points, which when compared to the control group with a mean dropout of 4.4 percentage points, infers a relative treatment effect of - 1.91 percentage points as show in the figure 7.

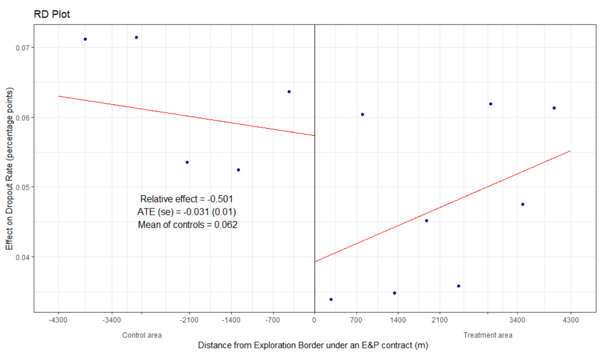


Figure 6: (a) Dropout of Males in Elementary School

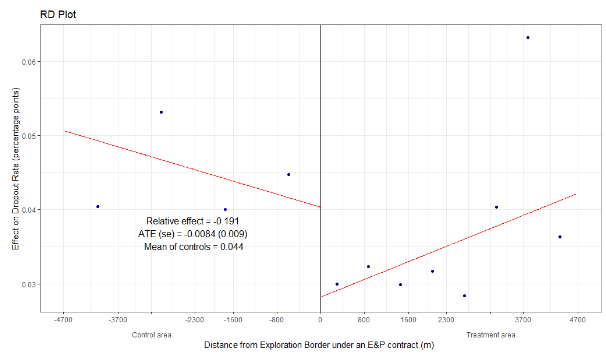


Figure 7: (b) Dropout of Females in Elementary School

The case for secondary school is similar, with men having a more significant and pronounced effect. Males in high school saw an increase of 2.3 percentage points with a standard deviation of 0.9 percentage points. When comparing this treatment effect with the control group, it is observed that the effect related to hydrocarbon exploration ads in secondary school men is an increase of 69.5 percentage points. In the case of women, no evidence of changes in desertion was found as we can see in the figure 8 and 9.

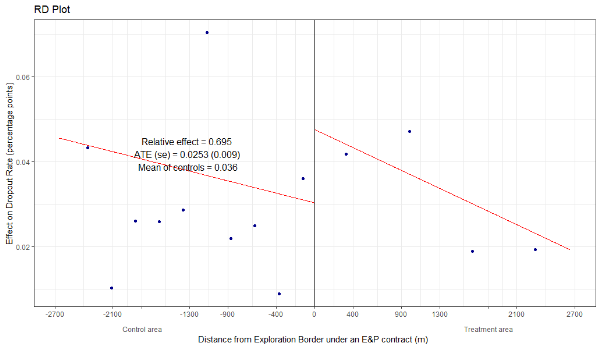


Figure 8: (a) Dropout of Males in Secondary School

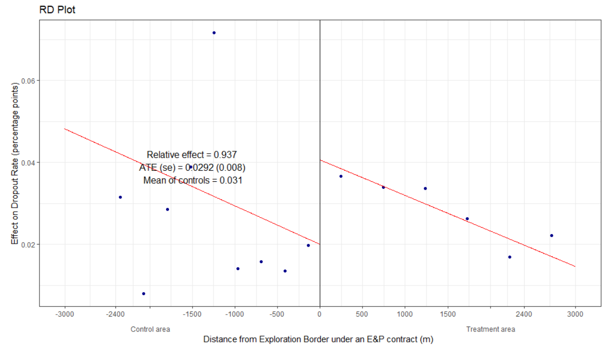


Figure 9: (b) Dropout of Females in Secondary School

These findings may support R. Rumberger (1995) claim that *"reasons for dropping out vary by gender, with women more likely to drop out due to pregnancy or marriage and men more likely to drop out for work."* .

Heterogeneities by grade level indicate that some courses may have a greater influence on the overall effect of oil exploration ads on dropout.

The third and fifth grades of primary school have negative effects on school dropout, while the transition, first, second, and fourth grades show no evidence of a significant effect. It is important to highlight the great effect that students in fifth grade have, which is the last grade of primary school. In this grade, a relative decrease of 69 percentage points in school dropout is shown, which indicates that the positive effect on school dropout in primary school is mainly given by students in the last grade (see figure 10)).

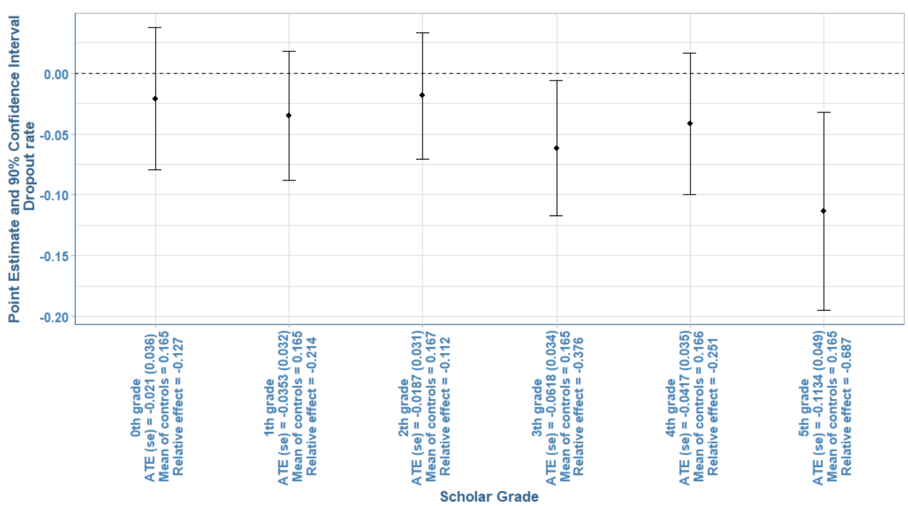


Figure 10: General Inference by Grade in Elementary School

In secondary school, a significant increase of between 7 percentage points and 17 percentage points is observed in school dropouts in a decreasing linear fashion from the eighth grade. The greatest dropout effect is observed in the tenth grade, which supports the estimate in the previously proposed theoretical model. In the tenth grade, it is observed that for every person who drops out of the control group, two people drop out of the treatment group, with a relative treatment effect of 103.9 percentage points, as seen in the figure 11.

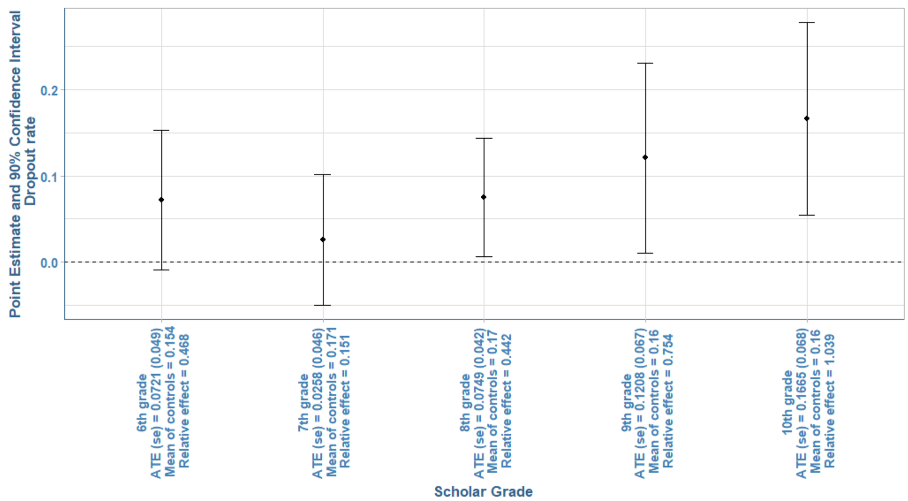


Figure 11: General Inference by Grade in Secondary School

6.2 Falsification and robustness tests

We evaluated the consistency of the results described above by means of forgery and robustness tests. First conduct falsification tests to ensure that the control and treatment groups are homogeneous and comparable. We then evaluate the bandwidth of the distance to verify the sensibility of our distance to the bandwidth.

The dropout results, as seen in Figure B.9 and the Figure B.10, are not sensitive to distance-bandwidth. By evaluating the bandwidth every 20 to 40 meters, we found that the dropout effect is consistent for all bandwidths. As mentioned in the previous results and in the theoretical framework, a decrease in the dropout rate of primary students and an increase in secondary students is observed for all distances. It can even be observed that the optimal bandwidth estimated by the Cattaneo methodology is in a zone that is very far from any change in the consistency of the estimate.

Discussion

This study significantly advances our understanding of the relationship between expected income shocks resulting from hydrocarbon exploration announcements and dropout rates in schools within exploration areas in Colombia. The rigorous research design employed in this study establishes a causal relationship between exploration announcements and dropout rates, providing valuable insights into the localized impact of economic shocks on educational outcomes. The study highlights a differentiated impact on dropout rates between elementary and secondary schools, revealing the need for tailored interventions and policies to address dropout challenges at each educational stage effectively. Additionally, the gender-specific impact of expected income shocks on educational outcomes underscores the importance of considering gender disparities in policy formulation to ensure equitable educational opportunities for boys and girls in resource-rich regions.

While the study offers significant contributions, it also acknowledges certain limitations that warrant attention. The findings' generalizability may be limited to the specific context of Colombia, necessitating replication in diverse regions with varying economic and educational characteristics to validate the results' broader applicability. Addressing potential endogeneity issues, such as unobservable confounders or reverse causality, through additional econometric techniques or natural experiments would strengthen the study's internal validity. Moreover, the study's call for further investigation into the mediating factors influencing students' decisions to stay in or drop out of school following income shocks highlights the need for in-depth explorations of underlying mechanisms.

Opportunities for future research lie in examining the long-term effects of exploration announcements on students' educational and economic trajectories to provide policymakers with a comprehensive understanding of sustained impacts. Investigating the role of socioeconomic context, including household income levels and parental education, could shed light on how these factors interact with income shocks to influence dropout rates. Exploring potential non-linear relationships between exploration intensity and dropout rates could reveal nuanced patterns in the data. Understanding the interplay between existing educational policies and economic shocks is crucial for designing effective interventions.

Building on the study's findings, future research should explore mediating interventions to mitigate the negative impact of exploration announcements on dropout rates. Evaluating the effectiveness of targeted programs that offer additional support, resources, or incentives to students and schools during economic uncertainty could help address the identified challenges. By acknowledging the study's limitations and delving into the areas identified for further research, we can deepen our understanding of the complex relationship between economic activities and educational outcomes. This knowledge is informing evidence-based policies and interventions aimed at promoting equitable and sustainable education in resource-rich regions.

7 Conclusion

In conclusion, this study investigates the impact of expected income shocks resulting from the announcement of hydrocarbon exploration on dropout rates in schools located within the exploration areas of Colombia. The main findings provide valuable insights into the complex relationship between natural resource exploration and educational outcomes.

The research reveals that elementary school pupils experience a significant reduction in dropout rates following exploration announcements. This positive effect is particularly pronounced among girls, indicating a potential gender-specific impact of expected income shocks on educational outcomes. However, a contrasting observation is made among secondary school pupils, where an increase in dropout rates is observed after the exploration announcement.

The implications of these findings are multifaceted. Firstly, they underscore the importance of considering the local impact of natural resource exploration announcements on educational outcomes when formulating educational policies in resource-rich regions. Policymakers should recognize that expected income shocks can have varying effects on different educational stages, and targeted interventions should be designed to address these disparities.

Secondly, the gender-specific impact observed in elementary schools calls for special attention to be given to the educational needs of both boys and girls in resource-rich areas. Efforts to reduce dropout rates should consider the specific challenges faced by each gender, ensuring that both boys and girls have equal access to quality education and are supported in staying engaged in their studies.

Thirdly, the contrasting effect in secondary schools highlights the vulnerability of students at this educational stage to the influence of exploration announcements. The substantial increase in dropout rates among secondary school pupils suggests the need for interventions that provide additional support and incentives to keep students motivated and committed to their education during periods of economic uncertainty.

Furthermore, the study's examination of heterogeneities, falsification, and robustness tests adds robustness to the main findings and further deepens our understanding of the factors influencing dropout rates in response to exploration announcements. The identification of grade-level differences in the impact of the announcements indicates that certain educational stages may be more sensitive to economic shocks, emphasizing the importance of targeted interventions at critical grade levels.

References

Abadie, A., & Cattaneo, M. D. (2018). Econometric methods for program evaluation. *Annual Review of Economics*, *10*(1), 465-503. Retrieved from https://doi.org/10.1146/annurev-economics-080217-053402 doi: 10.1146/annurev-economics-080217-053402

Administrative Department of National Planning. (2021). *Informe estadístico petrolero.* https://acp.com.co/web2017/es/publicaciones-e-informes/informe-estadistico-petrolero/692-iep-enero-2021.

Agencia Nacional de Hidrocarburos (ANH). (2012). *Historia del petróleo en colombia.* Retrieved from https://www.anh.gov.co/es/ambiental-y-social/regionalizaci%C3%B3n/historia-del-petr%C3%B3leo-en-colombia/

Baynard, C. W. (2011). The landscape infrastructure footprint of oil development: Venezuela's heavy oil belt. *Ecological Indicators*, *11*(3), 789-810. Retrieved from https://www.sciencedirect.com/science/article/pii/S1470160X10001767 doi: https://doi.org/10.1016/j.ecolind.2010.10.005

Belley, P., & Lochner, L. (2007, 12). The Changing Role of Family Income and Ability in Determining Educational Achievement. *Journal of Human Capital*, *1*(1), 37–89. Retrieved from http://dx.doi.org/10.1086/524674 doi: 10.1086/524674

Brisbois, B. W., Reschny, J., Fyfe, T. M., Harder, H. G., Parkes, M. W., Allison, S., . . . Oke, B. (2019). Mapping research on resource extraction and health: A scoping review. *The Extractive Industries and Society*, *6*(1), 250-259. Retrieved from https://www.sciencedirect.com/science/article/pii/S2214790X18302004 doi: https://doi.org/10.1016/j.exis.2018.10.017

Brueckner, M., & Gradstein, M. (2016, 6). Income and Schooling: Evidence from International Oil Price Shocks. *Journal of Human Capital*, *10*(2), 212–234. Retrieved from http://dx.doi.org/10.1086/686152 doi: 10.1086/686152

Brunnschweiler, C. N. (2008). Cursing the blessings? natural resource abundance, institutions, and economic growth. *World Development*, *36*(3), 399-419. Retrieved from https://www.sciencedirect.com/science/article/pii/S0305750X07002100 doi: https://doi.org/10.1016/j.worlddev.2007.03.004

Calonico, S., Cattaneo, M. D., & Farrell, M. H. (2018). On the effect of bias estimation on coverage accuracy in nonparametric inference. *Journal of the American Statistical Association*, *113*(522), 767–779.

Calonico, S., Cattaneo, M. D., & Farrell, M. H. (2020). Optimal bandwidth choice for robust bias corrected inference in regression discontinuity designs. *Econometrics Journal*, *23*(2), 192–210.

Calonico, S., Cattaneo, M. D., Farrell, M. H., & Titiunik, R. (2017). rdrobust: Software for regression discontinuity designs. *Stata Journal*, *17*(2), 372–404.

Calonico, S., Cattaneo, M. D., Farrell, M. H., & Titiunik, R. (2019). Regression discontinuity designs using covariates. *Review of Economics and Statistics*, *101*(3), 442–451.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014a). Robust data-driven inference in the regression-discontinuity design. *Stata Journal*, *14*(4), 909–946.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014b). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, *82*(6), 2295–2326.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2015a). Optimal data-driven regression discontinuity plots. *Journal of the American Statistical Association*, *110*(512), 1753–1769.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2015b). rdrobust: An r package for robust nonparametric inference in regression-discontinuity designs. *R Journal*, *7*(1), 38–51.

Cattaneo, M. D., Frandsen, B., & Titiunik, R. (2015). Randomization inference in the regression discontinuity design: An application to the study of party advantages in the u.s. senate. *Journal of Causal Inference*, *3*(1), 1–24.

Cattaneo, M. D., Idrobo, N., & Titiunik, R. (2020). *A practical introduction to regression discontinuity designs: Foundations*. Cambridge University Press. doi: 10.1017/9781108684606

Cerutti, P., Crivellaro, E., Reyes, G., & Sousa, L. D. (2019, jun 6). Hit and Run? Income Shocks and School Dropouts in Latin America. *LABOUR*, *33*(4), 533–566. Retrieved from `http://dx.doi.org/10.1111/labr.12156` doi: 10.1111/labr.12156

Checchi, D. (2004, mar 18). Does Educational Achievement Help Explain Income Inequality? In *Inequality Growth and Poverty in an Era of Liberalization and Globalization* (pp. 81–111). Oxford University PressOxford. Retrieved from `http://dx.doi.org/10.1093/0199271410.003.0004` doi: 10.1093/0199271410.003.0004

Chevalier, A., & Lanot, G. (2002, aug 1). The Relative Effect of Family Characteristics and Financial Situation on Educational Achievement. *Education Economics*, *10*(2), 165–181. Retrieved from `http://dx.doi.org/10.1080/09645290210126904` doi: 10.1080/09645290210126904

Colombian Ministry of Education. (2009). *Tasa de deserción escolar en Colombia.* https://www.mineducacion.gov.co/1621/articles-293659$_archivo_pdf_abc.pdf$.

Dahl, G. B., & Lochner, L. (2017, feb 1). The Impact of Family Income on Child Achievement: Evidence from the Earned Income Tax Credit: Reply. *American Economic Review*, *107*(2), 629–631. Retrieved from `http://dx.doi.org/10.1257/AER.20161329` doi: 10.1257/aer.20161329

Davis-Kean, P. E. (2005). The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. *Journal of Family Psychology*, *19*(2), 294–304. Retrieved from `http://dx.doi.org/10.1037/0893-3200.19.2.294` doi: 10.1037/0893-3200.19.2.294

Dube, O., & Vargas, J. F. (2013, 03). Commodity Price Shocks and Civil Conflict:

Evidence from Colombia. *The Review of Economic Studies*, *80*(4), 1384-1421. Retrieved from https://doi.org/10.1093/restud/rdt009 doi: 10.1093/restud/rdt009

Farzanegan, M. R., & Thum, M. (2018, sep 3). Does oil rents dependency reduce the quality of education? *Empirical Economics*, *58*(4), 1863–1911. Retrieved from http://dx.doi.org/10.1007/S00181-018-1548-Y doi: 10.1007/s00181-018-1548-y

Frederick, V. D. P. (2011, June). Natural resources: Curse or blessing? *Journal of Economic Literature*, *49*(2), 366-420. Retrieved from https://www.aeaweb.org/articles?id=10.1257/jel.49.2.366 doi: 10.1257/jel.49.2.366

Gibbs, B. G., & Heaton, T. B. (2014). Drop out from primary to secondary school in mexico: A life course perspective.

Harris, D. (2010). Education production functions: Concepts. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education (third edition)* (Third Edition ed., p. 402-406). Oxford: Elsevier. Retrieved from https://www.sciencedirect.com/science/article/pii/B9780080448947012306 doi: https://doi.org/10.1016/B978-0-08-044894-7.01230-6

Keele, L. J., & Titiunik, R. (2015). Geographic boundaries as regression discontinuities. *Political Analysis*, *23*(1), 127–155. doi: 10.1017/S0090591514000179

M. Björkman. (2013). *Income shocks and gender gaps in education: Evidence from uganda.*

Michael Bernard Coelli. (2005). *Parental income shocks and the education attendance of youth.*

Michelmore, K. (2013). The Effect of Income on Educational Attainment: Evidence from State Earned Income Tax Credit Expansions. *SSRN Electronic Journal*. Retrieved from http://dx.doi.org/10.2139/ssrn.2356444 doi: 10.2139/ssrn.2356444

Nguyen, T. T., Do, T. L., Halkos, G., & Wilson, C. (2020). Health shocks and natural resource extraction: A cambodian case study. *Ecological Economics*, *169*, 106517. Retrieved from https://www.sciencedirect.com/science/article/pii/S0921800919308183 doi: https://doi.org/10.1016/j.ecolecon.2019.106517

Pablo A. Peña. (2013). *Aggregate shocks and investment in human capital: higher educational achievement during the lost decade in mexico.*

Quintero Otero, J. D. (2020, 2). Not all sectors are alike: Differential impacts of shocks in oil prices on the sectors of the Colombian economy. *Energy Economics*, *86*, 104691. Retrieved from http://dx.doi.org/10.1016/j.eneco.2020.104691 doi: 10.1016/j.eneco.2020.104691

Rumberger, R. (1995). Dropping out of middle school: A multilevel analysis of students and schools.

Rumberger, R. W., & Thomas, S. L. (2000). The distribution of dropout and turnover rates among urban and suburban high schools. *Sociology of Education*, *73*(1), 39–67. Retrieved 2023-06-21, from http://www.jstor.org/

stable/2673198

Sala-i Martin, X., & Subramanian, A. (2012, 12). Addressing the Natural Resource Curse: An Illustration from Nigeria†. *Journal of African Economies*, *22*(4), 570-615. Retrieved from https://doi.org/10.1093/jae/ejs033 doi: 10.1093/jae/ejs033

Sangare, S., & Maisonnave, H. (2018). Mining and petroleum boom and public spending policies in niger: A dynamic computable general equilibrium analysis. *Environment and Development Economics*, *23*(5), 580-590. doi: 10.1017/S1355770X18000104

Stearns, E., & Glennie, E. (2006). When and why dropouts leave high school.

Steinmayr, R., Weidinger, A. F., Schwinger, M., & Spinath, B. (2019). The importance of students' motivation for their academic achievement – replicating and extending previous findings. *Frontiers in Psychology*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01730 doi: 10.3389/fpsyg.2019.01730

Zuo, N., Schieffer, J., & Buck, S. (2019, 2). The effect of the oil and gas boom on schooling decisions in the U.S. *Resource and Energy Economics*, *55*, 1–23. Retrieved from http://dx.doi.org/10.1016/J.RESENEECO.2018.10.002 doi: 10.1016/j.reseneeco.2018.10.002

A Appendix

A.1 Software: distancegeord in python language

```
!pip install distancegeord
from distancegeord import *
import pandas as pd
shape_polygon_path  ="./area_treatment.zip"
shape_units_path  ="./observation.zip"
data = distancegeord(shape_polygon_path, shape_units_path)
```

A.2 Figures empirical strategy

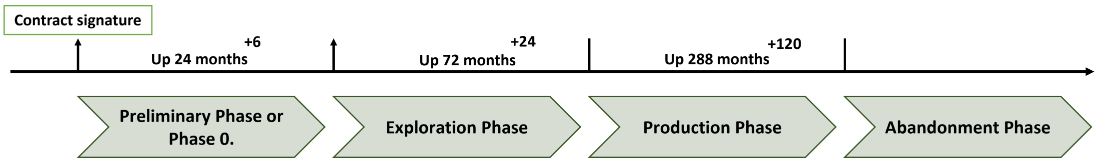


Figure A.1: The timeline of an E&P contract

B Data

Table B.1: Dictionary of the data based

Column Name	Description
CODIGO_DANE_SEDE	Code assigned to the school according to the DANE (National Administrative Department of Statistics)
GRADO	Grade level of the school, where grades less than 5 refer to elementary school and grades between 6 and 11 refer to secondary school
IS_IN_T1	Indicator of whether the data corresponds to the year immediately following the intervention
DESERTO_T1	School dropout rate in the year immediately following the intervention
ESTU_TOTALES_T1	Total number of students in the school in the year immediately following the intervention
STILL_SAME_SCHOOL_T1	Proportion of students who remain in the same school in the year immediately following the intervention
EMIGRATED_T1	Number of students who emigrated from the school in the year immediately following the intervention
IMIGRATED_T1	Number of students who immigrated to the school in the year immediately following the intervention
EMIGRATED_OUT_AC_AT_T1	Number of students who emigrated outside the administrative area of the school in the year immediately following the intervention
MALE_DROPOUT_T1	Number of male students who dropped out of school in the year immediately following the intervention
FEMALE_DROPOUT_T1	Number of female students who dropped out of school in the year immediately following the intervention
FEMALE_T1	Number of female students in the school in the year immediately following the intervention
MALE_T1	Number of male students in the school in the year immediately following the intervention
DESERTO_T2	School dropout rate two years after the intervention
ESTU_TOTALES_T2	Total number of students in the school two years after the intervention
STILL_SAME_SCHOOL_T2	Proportion of students who remain in the same school two years after the intervention
EMIGRATED_T2	Number of students who emigrated from the school two years after the intervention
IMIGRATED_T2	Number of students who immigrated to the school two years after the intervention
EMIGRATED_OUT_AC_AT_T2	Number of students who emigrated outside the administrative area of the school two years after the intervention
MALE_DROPOUT_T2	Number of male students who dropped out of school two years after the intervention
FEMALE_DROPOUT_T2	Number of female students who dropped out of school two years after the intervention
FEMALE_T2	Number of female students in the school two years after the intervention
MALE_T2	Number of male students in the school two years after the intervention
DESERTO_TL1	School dropout rate one year before the intervention
ESTU_TOTALES_TL1	Total number of students in the school one year before the intervention
STILL_SAME_SCHOOL_TL1	Proportion of students who remain in the same school one year before the intervention
EMIGRATED_TL1	Number of students who emigrated from the school one year before the intervention
IMIGRATED_TL1	Number of students who immigrated to the school one year before the intervention
EMIGRATED_OUT_AC_AT_TL1	Number of students who emigrated outside the administrative area of the school one year before the intervention
distance_to_polygon	Distance from the school to a specific polygon
COD_COL	Code assigned to the school
NOM_COL	Name of the school
DIR_COL	Address of the school
TEL_COL	Telephone number of the school
NOMBRE_DEPARTAMENTO	Name of the department where the school is located
NOMBRE_MUNICIPIO	Name of the municipality where the school is located
ZONA	Zone classification of the school

Continued on next page

Table B.1 – continued from previous page

Column Name	Description
COD_INST	Code assigned to the institution
NOM_INST	Name of the institution
SECTOR	Sector classification of the school
CONTRAT_ID	Identifier for the school contract
CONTRATO_N	Contract number
FECHA_FIRM	Date when the contract was signed
OPERADOR	Entity responsible for school administration
TIPO_CONTR	Type of contract
sd_geometry	Geometry information for spatial data
eap_geometry	Geometry information for spatial data
sede_long	Longitude coordinate of the school
sede_lat	Latitude coordinate of the school
COD_COL_ELEVATION	Elevation code assigned to the school
elevation	Elevation of the school
treatment	Treatment designation
ANNO_INF	Inflection year
SIMAT_YEAR	Year of SIMAT data
TOTAL_STUDENTS	Total number of students
FEMALE	Number of female students
MALE	Number of male students
NUEVO	Number of new students
REPITENTE	Number of repeating students
SUBSIDIADO	Number of subsidized students
EDAD	Age of students
ESTRATO_1	Number of students in socioeconomic stratum 1
ESTRATO_2	Number of students in socioeconomic stratum 2
ESTRATO_3	Number of students in socioeconomic stratum 3
ESTRATO_4	Number of students in socioeconomic stratum 4
ESTRATO_5	Number of students in socioeconomic stratum 5
ESTRATO_6	Number of students in socioeconomic stratum 6
FRAC_FEMALE	Fractional representation of female students
FRAC_MALE	Fractional representation of male students
FRAC_NUEVO	Fractional representation of new students
FRAC_REPITENTE	Fractional representation of repeating students
FRAC_SUBSIDIADO	Fractional representation of subsidized students
FRAC_EDAD	Fractional representation of student ages
FRAC_ESTRATO_1	Fractional representation of students in socioeconomic stratum 1
FRAC_ESTRATO_2	Fractional representation of students in socioeconomic stratum 2
FRAC_ESTRATO_3	Fractional representation of students in socioeconomic stratum 3
FRAC_ESTRATO_4	Fractional representation of students in socioeconomic stratum 4
FRAC_ESTRATO_5	Fractional representation of students in socioeconomic stratum 5
FRAC_ESTRATO_6	Fractional representation of students in socioeconomic stratum 6
CODIGO_DANE_SEDE_COV	Code assigned to the school in the COV database
GRADO_COV	Grade level of the school in the COV database
Q_artyl	Artyl value
YEAR_FRIM	Year of contract signature
GRADO_	Grade level
distance	Distance measurement
FRAC_ESTRATO_1_2	Fractional representation of students in socioeconomic stratum 1 and 2
FRAC_ESTRATO_3_4	Fractional representation of students in socioeconomic stratum 3 and 4

B.1 Result

B.2 Heterogeneities by gender and grade

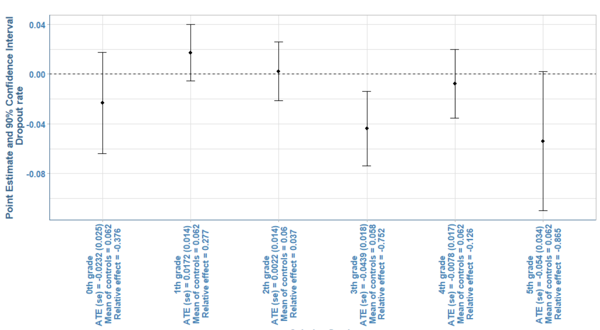


Figure B.1: Dropout of Males in Elementary School

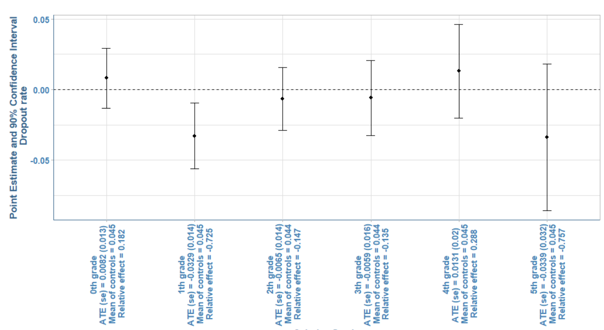


Figure B.2: Dropout of Females in Elementary School

Table B.2: Descriptive statistics of the control and treatment group

Variable	Treated Mean	Control Mean	Difference	$Pr(>\|t\|)$
Outcomes				
Female Dropout Rate	0.04 (0.11)	0.05 (0.13)	-0.01 (-0.018)	0
Male Dropout Rate	0.05 (0.12)	0.07 (0.14)	-0.011 (-0.017)	0
Dropout Rate	0.17 (0.26)	0.2 (0.28)	-0.028 (-0.014)	0
Female $\text{Dropout}_{\text{T2}}$	0.08 (0.13)	0.08 (0.15)	-0.006 (-0.014)	0.065
Male $\text{Dropout}_{\text{T2}}$	0.09 (0.15)	0.11 (0.18)	-0.015 (-0.024)	0
$\text{Dropout}_{\text{T2}}$	0.3 (0.34)	0.32 (0.34)	-0.024 (0.001)	0.003
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				
Emigrated Out	0.23 (0.28)	0.23 (0.29)	-0.006 (-0.012)	0.332
Immigrated	0 (0)	0 (0)	0 (0)	0.118
Emigrated	0 (0)	0 (0)	0 (0)	0.108
N Treated		4636		
N Control		3097		

Note: The table presents descriptive statistics of the control and treatment group. "Treated" and "Control" represent the mean values for the respective groups. "Difference" shows the differences between the treated and control groups. "$Pr(>|t|)$" indicates the p-value obtained from the t-test. The outcomes are presented in the first section of the table, and the covariates are shown in the second section. The "Robustness" section presents additional analysis results. The table includes descriptive statistics such as mean and standard deviation for various variables. This table provides valuable information for understanding the characteristics of the control and treatment groups and helps in assessing the differences between them.

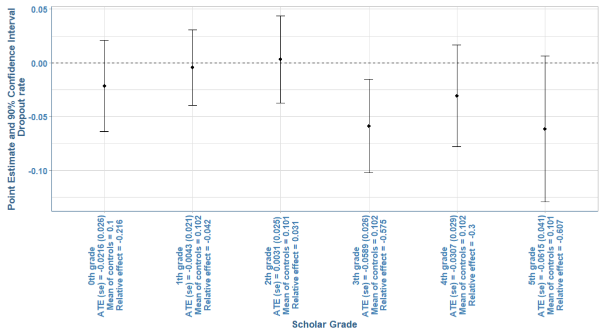


Figure B.3: Dropout of Males in Elementary School

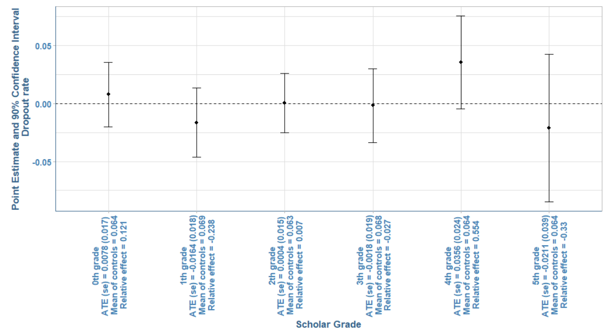


Figure B.4: Dropout of Females in Elementary School

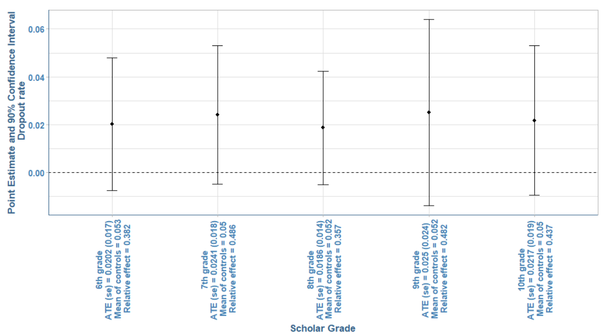


Figure B.5: Dropout of Males in Secondary School

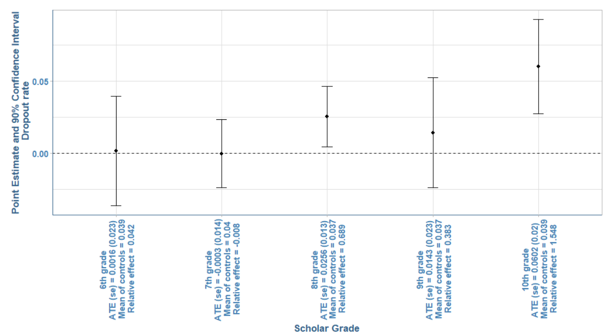


Figure B.6: Dropout of Females in Secondary School

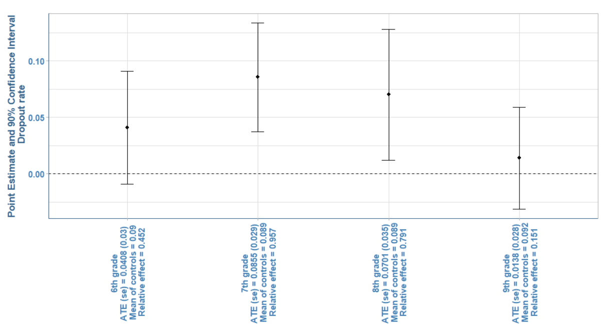


Figure B.7: Dropout of Males in Secondary School

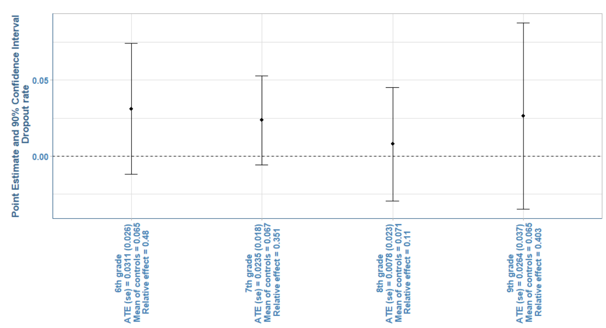


Figure B.8: Dropout of Females in Secondary School

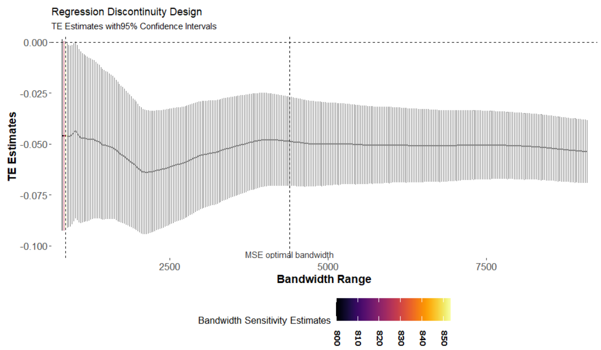


Figure B.9: Bandwidth sensibility test of students in Elementary School

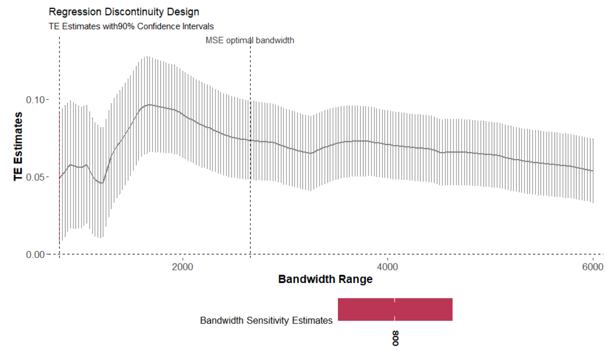


Figure B.10: Bandwidth sensibility test of students in Secondary School

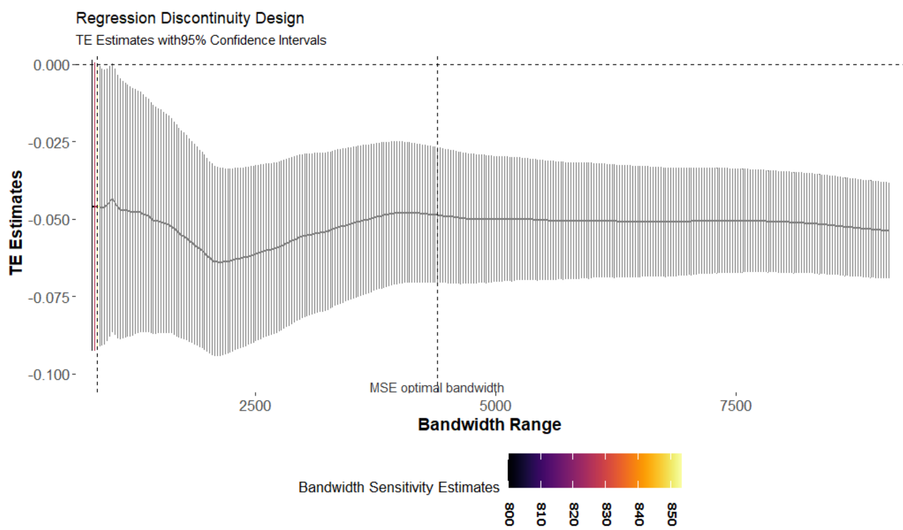


Figure B.11: General Bandwidth sensibility test in Elementary School

B.2.1 General Bandwidth sensibility by gender

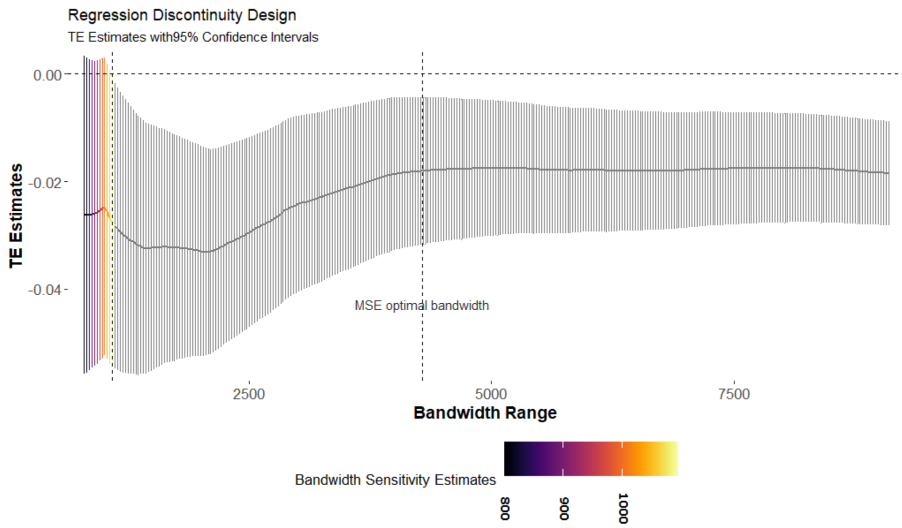


Figure B.12: Bandwidth sensibility test of males in Elementary School

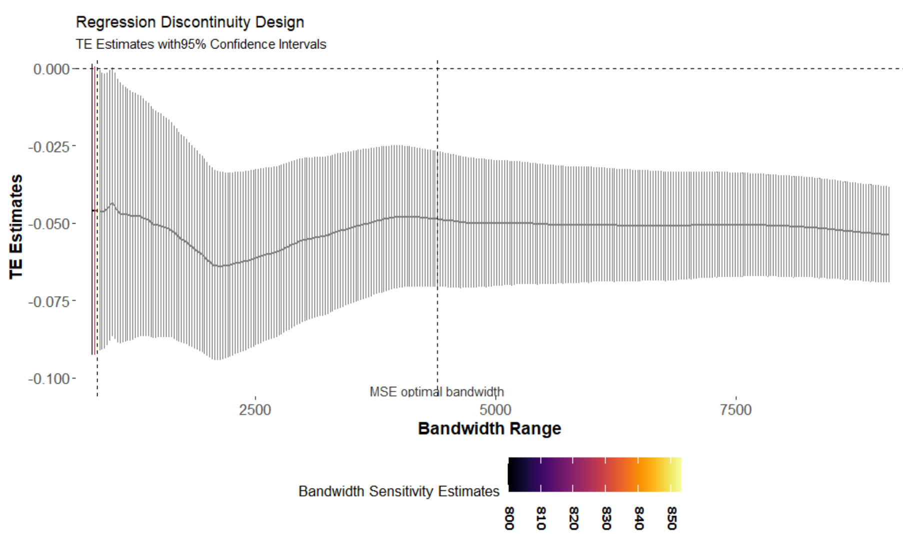


Figure B.13: General Bandwidth sensibility test in Elementary School

B.2.2 General Bandwidth sensibility by gender

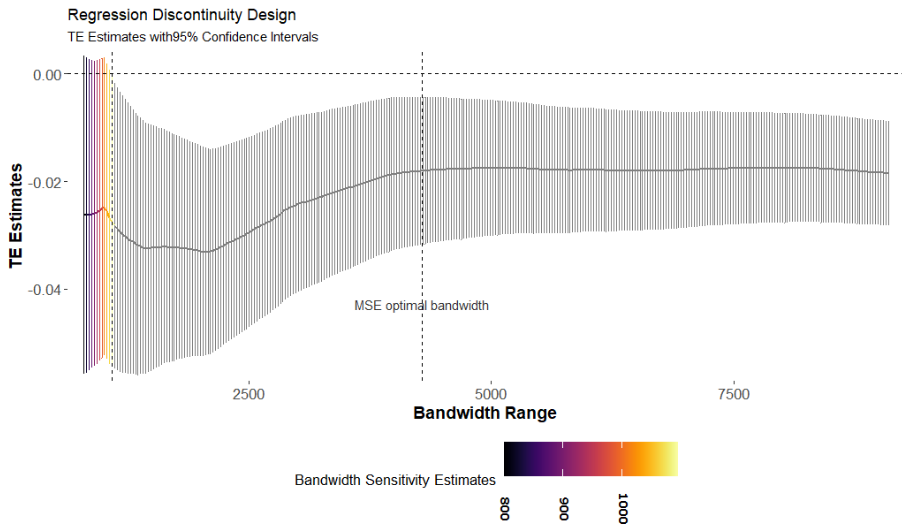


Figure B.14: Bandwidth sensibility test of males in Elementary School

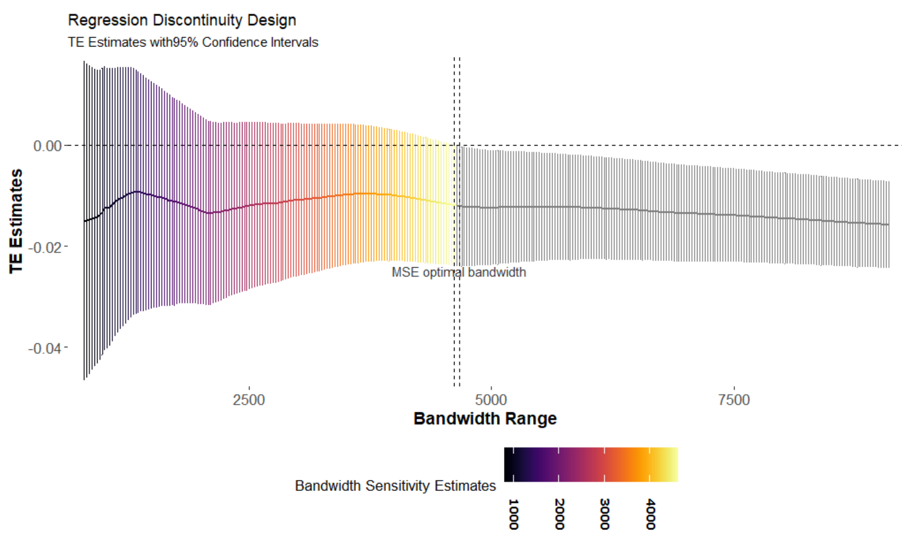


Figure B.15: Bandwidth sensibility test of females in Elementary School

C Robustness check

C.1 Control and treated schools differ systematically in this covariate?

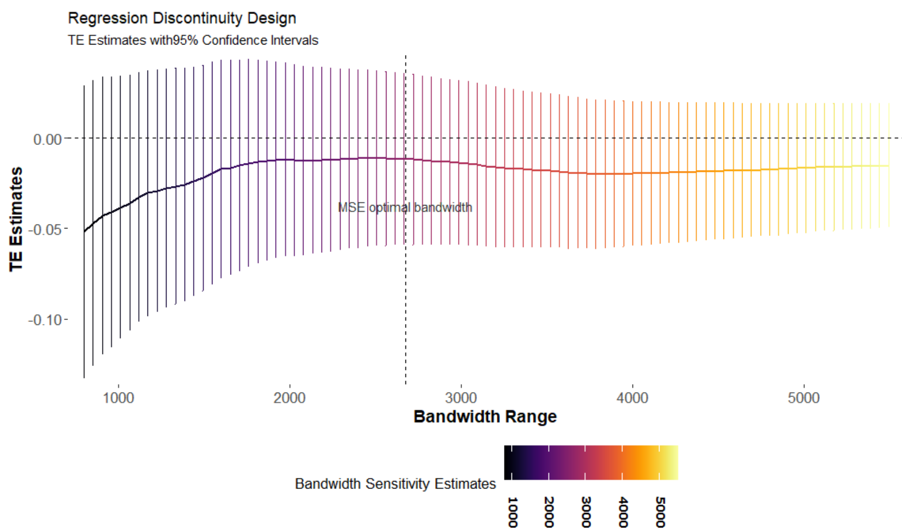


Figure C.1: Control and treated schools differ by FRAC FEMALE

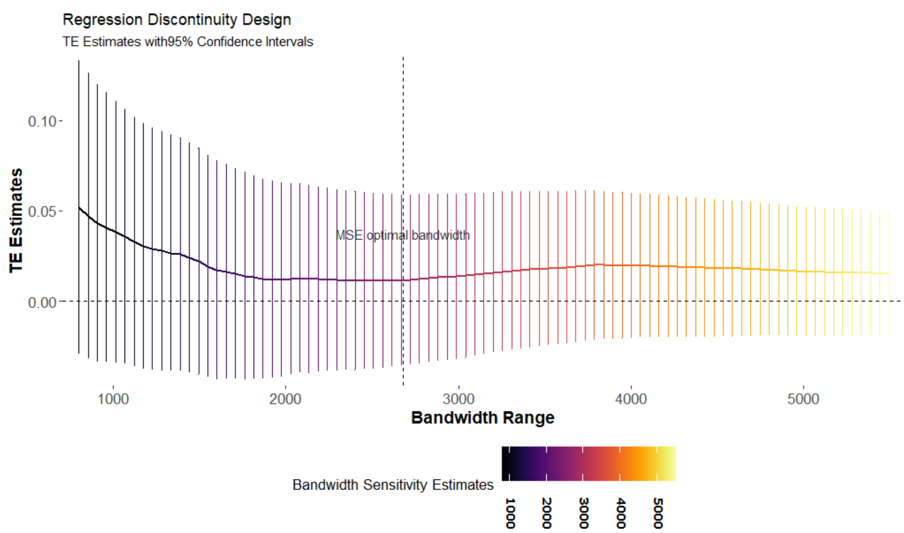


Figure C.2: Control and treated schools differ by FRAC MALE

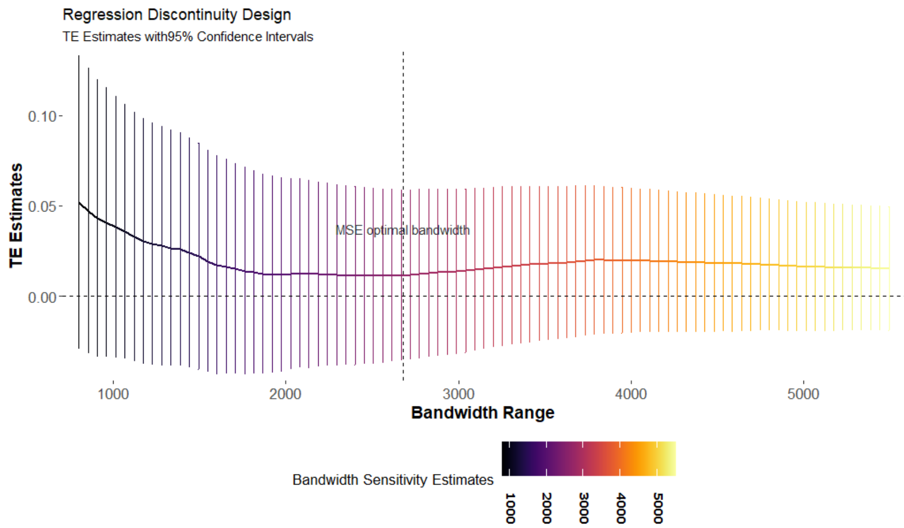


Figure C.3: Control and treated schools differ by FRAC NEW STUDENTS

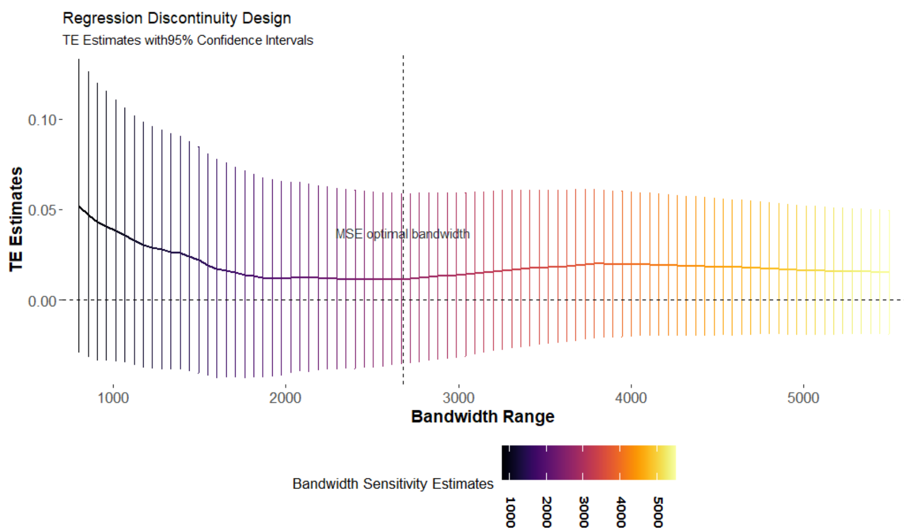


Figure C.4: Control and treated schools differ by FRAC REPEATERS

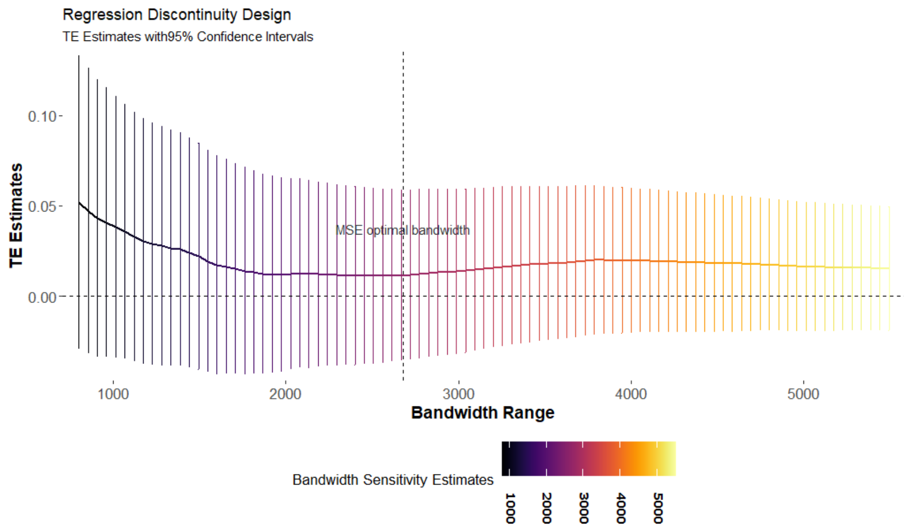


Figure C.5: Control and treated schools differ by FRAC SUBSIDIZED