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Civil Conflict and Educational Achievement: The Case of the Colombian Secondary School Exit Examination

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ABSTRACT: This paper examines the relationship between civil conflict and educational achievement in Colombia. We use multilevel analysis to deal adequately with the hierarchical structure of the data and an instrumental variables approach to tackle the possibility of bias associated with endogeneity. To the best of our knowledge, this is the first effort to understand the relationship between civil conflict and educational achievement in exit examinations through the use of multilevel analysis. The results show that the relationship between the intensity of the conflict and performance on exit examinations is not as straightforward as it may seem at first glance.

KEYWORDS: educational policy • education (*Thesaurus*) • exit exams • civil conflict • multilevel analysis (*author*)

This article is based on the author's PhD dissertation research, conducted at the Maastricht Graduate School of Governance, Maastricht University (The Netherlands).

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Conflicto Civil y Rendimiento Académico: El caso del examen final de enseñanza secundaria en Colombia

RESUMEN: Este artículo examina la relación entre el conflicto civil en Colombia y el rendimiento académico. Utilizamos el análisis multinivel para tratar adecuadamente la estructura jerárquica de los datos y un enfoque de variables instrumentales para abordar la posibilidad de sesgo asociado con endogeneidad. Hasta donde sabemos, este es el primer esfuerzo para entender la relación entre conflicto civil y rendimiento académico en los exámenes del país mediante el uso de análisis multinivel. Los resultados muestran que la relación entre la intensidad del conflicto y el desempeño en los exámenes finales no es tan simple como parece a primera vista.

PALABRAS CLAVE: política educativa • educación (*Thesaurus*) • exámenes finales • conflicto civil • análisis multinivel (*autor*)

Conflicto civil e rendimento acadêmico: o caso do exame de estado da educação média na Colômbia

RESUMO: este artigo examina a relação entre o conflito civil e o rendimento escolar na Colômbia. Utilizamos uma metodologia de análise multinível para analisar adequadamente a estrutura hierárquica dos dados, e de variáveis instrumentais para abordar a possibilidade de vies associado à endogeneidade. De acordo com nossa revisão de literatura, este é o primeiro esforço para entender a relação entre o conflito civil e o rendimento nos exames de Estado usando análise multinível. Os resultados mostram que a relação entre a intensidade do conflito e o rendimento nos exames não é tão simples quanto parece à primeira vista.

PALAVRAS-CHAVE: educação (*Thesaurus*) • análise multinível • conflito civil • exames de rendimento (concluintes) • política educativa (*autor*)

Introduction

Civil conflict has significant economic, social and political repercussions that can potentially affect the educational achievement of individuals (Justino 2010). Nevertheless, this important issue has been insufficiently addressed in the literature on civil conflict and education. The purpose of this paper is to explore the relationship between civil conflict and educational achievement in Colombia during a period of escalation of violence (2002), through the use of multilevel analysis. Multilevel analysis is employed in this paper in order to deal adequately with the hierarchical structure of the data by simultaneously modeling variables at different levels without resorting to aggregation or disaggregation of the dataset. Taking advantage of a unique database managed by a Colombian think tank (the Resource Centre for Conflict Analysis - CERAC) that contains records of civil conflict events in Colombia, a government-kept database containing the results of standardized tests at different levels of schooling, and additional information about schools and teachers from Colombia's National Administrative Department of Statistics (DANE), we were able to construct a multilevel model to further investigate the relationship between civil conflict and educational achievement.

Our attention in this paper concentrates on students residing in conflict and non-conflict zones who participate in the Colombian formal education system. Hence, the objective of this research is to better understand the relationship between educational achievement and civil conflict amongst the students who participate in the formal education system. Although at first glance it might seem straightforward to think that there is a negative relationship between civil conflict and education, there are reasons to think that this relationship is not as straightforward as it seems.

For instance, the existing literature regarding the relationship between educational enrolment and civil conflict has shown mixed results. Swee (2009) and Bellows and Miguel (2006) find no significant effects of civil war on enrolment, whereas Lai and Thyne (2007) and Akresh and de Walque (2008) find evidence to show that civil war has a negative effect on enrolment rates. Furthermore, the researchers that have studied the relationship between education, conflict and gender have also reported mixed results. That is the case of Shemyakina (2011) and Annan *et al.* (2011), who have obtained totally different results in their studies of the impact of armed conflict on school enrolment by gender. The lack of consistency in the existing literature regarding the relationship between conflict and education casts doubts on the results obtained to date and motivates further research on this topic in order to explore the relationship in more detail.

This paper contributes to the existing literature on the relationship between civil conflict and education, including the contributions of Swee (2009), Akresh and de Walque (2008), Merrouche (2006), Lai and Thyne (2007), Shemyakina (2011), Debalen and Paul (2012), Bundervoet (2012), and Bellows and Miguel (2006). These research efforts have focused on the relationship between school enrolment, gender, years of education and civil conflict, but have not studied the relationship between civil conflict and academic achievement as measured by standardized examinations. To date, the only attempt to understand the relationship between civil conflict and educational achievement on standardized examinations was made by Rodriguez and Sánchez (2010), demonstrating that this area of research is very much understudied. This paper differs significantly from Rodriguez and Sánchez (2010) because it incorporates the hierarchical structure of the data into the analysis and use an innovative dataset regarding the civil conflict in Colombia. In fact, to the best of my knowledge, this is the first effort to understand the relationship between conflict and achievement on standardized exams through the use of multilevel analysis.

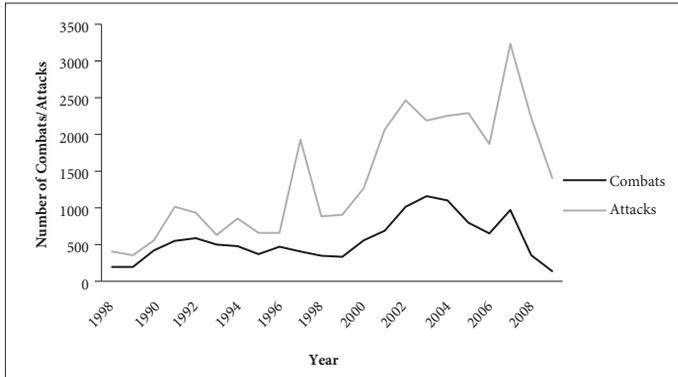
The rest of the paper is organized as follows: section 1 presents a brief description of the Colombian civil conflict; section 2 reviews the existing literature; section 3 presents the theoretical framework; section 4 describes the data and variables used in the analysis; section 5 describes the methodology employed for the analysis and discusses the specification of the model; section 6 reports the main results of the analysis; section 7 presents a discussion of the results; and the last section consists of the concluding remarks.

1. The Colombian Civil Conflict

The Colombian conflict is considered to be a conflict of long duration and variable intensity. Two violent actors have been the major players behind the conflict: the guerrilla groups and the paramilitary groups. These illegal actors went through a period of re-organization between 1991 and 1994 because of a major cut-back in available resources due to the end of the Cold War. This re-organization led to changes in their operative and financial structures. More specifically, during the first half of the nineties these illegal groups expanded their territorial presence throughout the country. However, according to Restrepo, Spagat and Vargas (2006), the violence did not increase at that time. It was not until the year 1996 that the dynamic of the conflict started to change significantly, meaning that the re-organization that took place during the first half of the nineties had a lagged effect on this dynamic. According to these authors, there was an important increment in the intensity of conflict and in the frequency of combats and

attacks that took place during that period (Graph 1). The re-organization period revitalized these illegal groups, allowing them to grow and gain power.

Graph 1. Number of Combats/Attacks



Source: CERAC Database.

Restrepo, Spagat and Vargas (2006) have called this “the escalation of violence” period, given the increase in the intensity of the conflict and the frequency of combats and attacks. According to these researchers, the escalation period extended from 1996 to 2002, the year in which the armed conflict reached its highest intensity. The recrudescence of violence in Colombia during those years can be explained by a number of factors. According to these authors, some of the factors that should be highlighted are: the unification of the majority of paramilitary groups into a single organization (*Autodefensas Unidas de Colombia*), the implementation of a strategy of terror against civilians, and the modernization of Colombia’s military forces through the implementation of new technologies to enable them to respond more effectively to the attacks of illegal groups. It should also be noted that during the escalation period the illegal groups implemented a strategy that focused on attacking civilians as a way to terrorize society. In this paper, we study the relationship between civil conflict and educational achievement, concentrating on the year 2002 when the effect on civilians was at its peak.

2. Review of the Literature

A number of researchers have contributed to the literature on the relationship between civil conflict and education. What is notable is that, to the best of our knowledge, only Rodríguez and Sánchez (2010) have tried to understand and quantify the impact of civil conflict on educational achievement as measured by

standardized exams. This area of research is very much understudied, leaving an important gap in the literature. The research efforts that have been done to date mostly focus on the relationship between school enrolment, years of education, gender and civil conflict.

Some researchers have analyzed the relationship between conflict and school enrolment. Swee (2009) uses data on war casualties in the Bosnian War (1992-1995) at the municipal level to study the effects of civil war on schooling attainment. The results show that individuals affected by war are less likely to complete secondary schooling, but there are no significant effects of war on the completion of primary schooling. Bellows and Miguel (2006) find no significant effects of civil war on enrolment in their analysis of the aftermath of the civil conflict in Sierra Leone that started in 1991 and lasted until 2002. The results show that there is no evidence of persistent adverse effects of civil war on local institutions. Another study by Akresh and de Walque (2008) contradicts the findings of Swee (2009) and Bellows and Miguel (2006). For this analysis, the researchers used two cross-sectional household surveys collected before and after the Rwandan genocide to study how genocide affects children's school enrolment and their probability of completing a particular grade. The results show that children who had been exposed to the trauma of genocide experienced a drop of almost one-half year of completed schooling, and were 15 percentage points less likely to complete third or fourth grade (Akresh and de Walque 2008). In line with the results obtained by Akresh and de Walque, Lai and Thyne (2007) also show evidence of the destructive effects of civil war on education. These researchers found evidence showing that during periods of civil war there are significant declines in expenditure and enrolment rates.

Merrouche (2006) studies the relationship between conflict and years of education using data from Cambodia. For this analysis, the author used instrumental variables regressions and a difference in differences approach to identify the effects of landmines on years of schooling. The results show that exposure to landmines caused an average loss of 0.4 years of education in Cambodia. Another study by Dabalen and Paul (2012) estimates the causal effect of civil war on years of education in a cohort of students who were exposed to armed conflict in Côte d'Ivoire. Their results show that war has a detrimental impact on education. Bundervoet (2012) studies the impact of poor childhood health associated with conflict on educational attainment using panel data from Burundi. The results show that children who were malnourished had on average fewer years of education. It is important to note that even though Merrouche (2006), Dabalen and Paul (2012), and Bundervoet (2012) used different empirical strategies, their results lead to similar conclusions.

Other researchers have focused their work on the relationship between education, conflict and gender. Annan *et al.* (2011) study the gender-based impacts of war using a quasi-experiment conducted in Northern Uganda. Their results show that longer abductions are associated with lower human capital among males, but they do not see any correlation between abduction length and human capital in the case of females. These authors show that males receive 0.51 fewer years of education for every year of abduction. The researchers also find that females who are forced to bear children during their abduction have more than a year less education than other females, abducted or not abducted. Annan and Blattman (2010) find similar results using survey data from Uganda. Their results show that the abducted have 0.7 fewer years of schooling. In another study, Shemyakina (2011) examines the case of Tajikistan, a country located in the former Soviet Union region that was involved in civil war from 1992 to 1998. That researcher used a difference in differences technique to study whether exposure to conflict affects school enrolment. Her results show that conflict has a significant negative effect on the enrolment of girls, but little or no effect on the enrolment of boys (Shemyakina 2011). The results obtained by Shemyakina are completely different from those obtained by Annan *et al.* (2011) and Annan and Blattman (2010).

Nevertheless, the results obtained by Shemyakina (2011) are supported by the work of Valente (2011) and Singh and Shemyakina (2013). Valente (2011) estimates the impact of conflict intensity on education in Nepal, exploiting intra- and inter-district variations in the intensity of violence. The results show that conflict intensity had a small positive effect on female educational attainment, whereas male schooling was not significantly affected by the intensity of conflict. Another study by Singh and Shemyakina (2013) ratifies the findings obtained by Shemyakina (2011). Singh and Shemyakina (2013) examine the gender-specific effect of the Punjab insurgency on the educational attainment of adults who were between 6 and 16 years of age at the time of the insurgency. The findings obtained by these researchers show a significant effect of the Punjab insurgency on educational attainment by girls. Specifically, for one standard deviation increase in the number of killings between 1981 and 1993, women from the affected cohort attained about 0.69 fewer years of education. This finding is particularly important considering that women in Punjab have only 4.83 years of education on average.

To date, the only attempt to understand the relationship between civil conflict and educational achievement on standardized examinations was made by Rodríguez and Sánchez (2010) using data from Colombia. These two researchers used an instrumental variables approach to control for possible measurement errors and problems of endogeneity. Rodríguez and Sánchez (2010) instrument the number of attacks in a municipality with the homicide capture rate at the

state level. The authors find that an increase in one standard deviation on the average number of attacks by armed groups to which students are exposed during secondary education decreases the Institute for the Promotion of Higher Education (ICFES) test score in 0.46 standard deviations. Rodríguez and Sánchez's paper is a pioneering analysis of the effects of conflict on schooling achievement on standardized exams, but there is still a lot of ground to be covered in this area of research. This paper differs significantly from Rodríguez and Sánchez (2010) because we incorporate the hierarchical structure of the data into the analysis.

3. Theoretical Framework

School-aged individuals are confronted with the need to make a decision regarding their desired level of education. They have to decide whether to continue studying, to join an illegal armed group present in their town, to drop out for other personal reasons, or to find a job to contribute to their household income. In order to take that decision, individuals must weigh the costs associated with a given level of education, the expected benefits of a higher level of education, the expected benefits of dropping out for other personal reasons, the expected benefits of joining an illegal armed group, and the expected income derived from finding a full-time job. Students residing either in conflict or non-conflict zones who decide to continue with their formal education are the ones we focus on in this study. As a matter of fact, given data restrictions, it is only possible to study empirically the case of students who can be observed —i.e., formal-education students who remain in the conflict zone and formal education students who live in non-conflict zones.

The literature has traditionally modeled schooling decisions (quantity and quality of education) using an educational production function. Let us consider the education production function specification proposed by Hanushek (1979) and Todd and Wolpin (2003).

Following Todd and Wolpin's notation, let T_{it} be a measurement of educational outcomes for student i in period t . As Hanushek highlights, it is essential to use adequate measurements of educational outcomes in order to analyze school production. However, measuring these outcomes is not an easy task. It is possible to find many different measurements of educational outcomes in the literature, including school attendance rates, school enrolment rates, exit exam scores, and dropout rates. Nevertheless, for the purposes of this article the exit exam scores are going to be employed as a measurement of educational outcomes. According to Hanushek, most educators and policy makers believe that standardized examinations are important measurements of education. In

fact, the results of national exams are used to evaluate educational programs and in some countries they are also used as a criterion for allocating funds to schools. Additionally, the scores on standardized exams are now being used in many places as a requisite for graduation from secondary school. Moreover, certain scores are required in order to go on to higher education.

Inputs are given by the choices that are being made by parents and schools. The vector of inputs supplied by parents at a given age is represented by F_i . According to the literature, family and individual background variables play a crucial role in educational performance (Häkkinen *et al.* 2003; Haveman and Wolfe 1995; Wößmann 2003). Family inputs are often times measured by the socio-demographic characteristics of the families. In this article, nine different variables are included to account for family background: home ownership, number of people contributing to household income, monthly household income, father's educational level, mother's educational level, number of brothers/sisters, number of family members, number of family members supported by the household income, and whether the family has a home mortgage.

A number of these variables (home ownership, number of people contributing to household income, monthly household income, and whether the family has a home mortgage) are related to the family's sources of income. The literature has shown that family income is related to educational achievement. The research done by Belley and Lochner (2007) and Davis-Kean (2005) has shown that relationship by examining cross-sectional and longitudinal datasets. The inclusion of the parental education variables (father's educational level and mother's educational level) is also particularly important considering that such studies, including those of Wößmann (2003) and Häkkinen *et al.* (2003), have found that students whose parents have a higher level of education show better performance than those whose parents have a low level of education. This may be the case because of genetic transmission of skills from parents to children, and because highly educated parents tend to provide a cultural environment that favours learning.

Family size also plays an important role in educational performance. Two variables were considered to account for this: number of brothers/sisters and number of family members. Downey (1995) and Blake (1981 and 1989) have found that as family size increases resource dilution causes an inverse relationship between the number of siblings and educational performance. This finding is explained by the fact that parents have limited resources (time, energy, money, etc.) that have to be divided amongst more children as the size of the family increases (Downey 1995).

The vector of school-supplied inputs is represented by S_i . The academic literature has found evidence showing that the characteristics of the schools and

teachers have a significant role in determining educational achievement. In fact, Gamoran and Long (2007) have found that the characteristics of the schools have an important impact on academic performance in developing countries. In this article, we consider eight different variables to account for school characteristics: number of students per teacher, basic infrastructure (water, sewage, and energy service), cost of tuition, number of students enrolled, school schedule (day/night), lab space per student, and classroom space per student.

The literature has highlighted the importance of school facilities as determinants of academic outcomes (Schneider 2002). The justification for this is particularly simple: how can students be high achievers if school infrastructure is inadequate? The research done by Earthman and Lemasters (1998) found that there is a positive relationship between adequate school infrastructure and higher test scores. Earthman (2002) points out that school building components have a measurable influence on student learning. Indeed, according to his study, “in cases where students attend school in substandard buildings they are definitely handicapped in their academic achievement [...] correlation studies show a strong positive relationship between overall building conditions and student achievement” (2002, 1). The number of available teachers per student in the school is also considered an important determinant. If a large group of students receives class from only one teacher, they will most likely receive less attention and this may have a negative effect on student achievement in evaluations. Additionally, a low number of teachers per student may be a factor discouraging school attendance.

D_i denotes external factors, in this case the intensity of the conflict, affecting student i . The intensity of conflict is included as a determinant of the educational production function because cognitive achievement may be affected in numerous ways by exposure to conflict. Conflict directly affects educational achievement because it reduces the amount of family resources available for education. This is the case because labor opportunities tend to be limited in conflict zones and households there have a higher level of exposure to violent attacks, which can result in the destruction of family assets. Additionally, conflict zones are very prone to attacks that cause damage to or destruction of the available public and private infrastructure. This also reduces the prospects of private investment in the conflict zone. However, the effects are not restricted only to the direct effects mentioned previously. Camacho (2008) points out that conflict generates disproportionate amounts of fear and stress amongst the population. Said researcher highlights the fact that the fear and stress generated leads to indirect effects that may be even more significant than the direct effects. Indeed, Camacho finds that the intensity of random landmine explosions that women experience during the first trimester of pregnancy has a significant negative effect on their babies' birth weight. Other

indirect effects of conflict highlighted by that author include reduced quality of life, anxiety, depression, sadness, disabilities, psychological stress, and other illnesses that deteriorate the process of human capital accumulation.

Finally, the student's endowed ability is denoted as μ_{io} , and a measurement error in test scores as ε_i .

Given these inputs, the production function is represented as:

$$T_i = T(F_i, S_i, D_i, \mu_{io}, \varepsilon_i) \quad (1)$$

Missing data for past inputs poses an important problem at the time of estimation. In order to overcome that problem, Todd and Wolpin (2003) came up with a specification that depends only on contemporaneous measurements of school and family inputs. This contemporaneous specification is often adopted because of data limitations associated with limited availability of historical input measurements or historical test score results. Behind the implementation of a contemporaneous specification we are assuming that ε_{it} is an additive error that includes any omitted factors, including past inputs and endowed capacity, as well as the possibility of measurement error. Therefore, in equation (1) the residual term includes all the omitted factors.

4. Data and Variables

A cross-sectional dataset containing the nation-wide results of the Colombian secondary school exit examination for the second semester of the year 2002 was employed in the analysis. After cleaning the dataset of observations that presented inconsistencies or had incomplete information, we were left with 77% of the observations reported in the raw dataset. The clean dataset encompasses the results from 284,492 students enrolled in 6,167 schools in 1,011 municipalities.

a. Main Sources of Information

The information that was used to construct the dataset for this empirical exercise came from three main sources: DANE, ICFES, and CERAC.

The DANE is in charge of administering statistical censuses to collect information about schools, students, and teachers. The C-100 is an annual statistical census that was administered until the year 2002 in order to collect information about school infrastructure and available supplies. On the other hand, the C-600 is an annual statistical census that collects information about students and teachers from all formal-education schools in Colombia. In this paper we use information from both these censuses in order to control for a number of characteristics of the schools, teachers, and students.

Databases containing the nation-wide results of Colombia's secondary school exit examination (Saber 11), as well as information about the socio-economic

features of the students who took the exam, which were made public by the Colombian Institute for the Promotion of Higher Education (ICFES) for research purposes, were also employed in this paper.²

Information about conflict events was obtained from the CERAC, a think tank based in Bogota (Colombia) that has three main lines of research: violent conflict, political violence, and violence associated with drug trafficking. Following these lines of research, one important area of study at CERAC is the quantification of violence directly associated with the internal armed conflict in Colombia. To quantify violent armed conflict, the research team at CERAC has developed a methodology to collect, document, code and register information. In this paper we use the number of casualties reported in CERAC's database as a municipal-level measurement of the intensity of conflict.

We also used data from the Colombian Federation of Municipalities and the Agustín Codazzi Geographic Institute in order to account for the characteristics of Colombian municipalities.

b. Variables

Our analysis focuses on two outcome variables: the score on the mathematics exam and the score on the language exam. Table 1 presents the statistics of the scores obtained by students on the mathematics and language secondary school exit examinations. The scoring scale for this exam ranges from 0 to 100.

Table 1. Language and Math Scores on the Secondary School Exit Examination (mean and standard deviation)

	2002-2	
	Mean	Standard Deviation
Math Score	43.21	6.34
Language Score	48.76	6.81
Observations	284492	

Source: Author's calculations.

2 It should be noted that in this paper we are going to use only the scores students obtained on the mathematics and language examinations as proxies of educational achievement. The results obtained on these two examinations are particularly important since they are designed to measure quantitative and verbal skills.

The literature shows that family and individual background variables play a crucial role in educational performance (Häkkinen *et al.* 2003; Haveman and Wolfe 1995; Wößmann 2003). The educational background of the parents of the students in the sample is particularly important. On average, 29% of the mothers had completed at least secondary school, while 25% of the fathers had completed that same level of schooling. Furthermore, around 7% of the mothers had completed a university degree, whereas around 9% of the fathers had completed a university degree. For the econometric exercise presented in this paper, we divided the parental education variable into the following four categories: no education (parent did not complete any level of studies), low level of education (elementary school), intermediate level of education (secondary school and/or technical studies) and higher level of education (university/graduate school).

There is a higher percentage of female students in the sample: only 45.7% of the students taking the examination were males, while 54.3% were females. There is a higher percentage of male students who work: 10.70% of the male students had a job, while only 6.84% of the female students did.

Table 2 summarizes all the other relevant familial, school, and municipal level variables, including the minimum and maximum values, and the mean and standard deviation.

Table 2. Descriptive Statistics

	2002-2			
	Mean	Standard Deviation	Min	Max
Family Background Variables				
Age	17.8	3.36	12	67
Home ownership (dummy: 1 = owns house)	0.72	0.45	0	1
Number of people contributing to household income	1.59	0.78	0	9
Number of family members	5.05	1.56	1	9
Number of brothers/sisters	2.77	1.88	0	9
Number of family members supported by the household income	0.73	1.02	0	9
Home mortgage (dummy: 1 no debt)	0.25	0.43	0	1
School Level Variables				
Number of students per teacher	188.68	116.89	6.29	500
Sewage service (dummy: 1 = school has the service)	0.88	0.33	0	1

	2002-2			
	Mean	Standard Deviation	Min	Max
Number of students enrolled	1869.45	1924.33	62	13118
School schedule (dummy: 1 = school meets during the day; 0 = school meets at night)	NA	NA	NA	NA
Lab space per student (m ²)	0.23	1.21	0	38.9
Classroom space per student (m ²)	1.41	2.01	0.5	34.6
Municipal Level Variables				
Financial resources assigned by the government to education (thousands of Colombian pesos)	1.62e+08	2.73e+08	393.47	6.79e+08
Degree of 'rurality' (0 to 1: 1 = completely rural)	0.20	0.26	0	1
Unsatisfied basic needs	24.51	18.65	5.43	100
Size (km ²) of the municipality	973.08	1382.96	139.7	65674
Population of the municipality	1741020	2598881	1095	6712247
Total expenditure (millions of Colombian pesos)	8.92e+08	1.56e+09	2738	3.86e+09

Source: Author's calculations.

There is consensus in the literature regarding the significant role of school and teacher characteristics in determining educational achievement (Barnett *et al.* 2002; Earthman and Lemasters 1998; Earthman 2002; Gamoran and Long 2007; Hanushek and Luque 2003; Hanushek 1986; Harbison and Hanushek 1992; Vandenberghe and Robin 2004).

For the econometric exercise, we divided the cost of tuition variable into four categories comprising the different levels of tuition paid by the students in the sample. The four categories are the following: no tuition (students pay nothing), low tuition (students pay less than \$25 dollars per month), medium tuition (students pay between \$25 dollars and \$100 dollars per month) and high tuition (students pay more than \$100 dollars per month). Most of the schools are either free (35%) or charge a tuition of more than US\$100 (36%). This can be explained by the dichotomy between public and private education. Public education in Colombia is free in most cases, while most private schools tend to charge a high tuition.

Central government resources are an important source of income for schools. In order to indicate that fact, and also to account for financial differences between municipalities, a variable that indicates the resources that are transferred by the

central government to the territorial entities to finance education expenditure is included in the model. This variable was transformed to logarithms.

Municipalities can be characterized according to the percentage of rural population that they have (rurality). To calculate the degree of 'rurality' of each municipality, a *rurality* index was calculated by dividing the rural population by the total population of each municipality. This *rurality* index goes from 0 to 1. The unsatisfied basic needs index at the municipal level is also included in order to indicate differences in the poverty levels of the municipalities considered in the analysis.

It is also important to account for geographic characteristics as part of the analysis. Two variables were included in the model in order to control for the size of the municipalities and their population density. The first variable indicates the area of the municipality in km², and the second variable indicates the number of inhabitants within the municipality. The altitude and the distance from the departmental capital (kilometers) were also included to indicate geographical characteristics that can also affect student performance on the examination.

5. Methods

In this paper we present the results of research done using two methodologies to study the relationship between conflict intensity and achievement scores on Colombia's secondary school exit examination: multilevel analysis and an instrumental variables approach.

a. Multilevel Analysis

In the analysis of educational datasets, students are traditionally grouped within classes, and classes are usually nested in schools. Furthermore, an important characteristic of educational datasets is that they usually have predictors for variables at the different levels. This implies that a central task for researchers is to put together these variables into an adequate method of analysis (de Leeuw and Meijer 2008). If groupings are established, even if they are random, they will tend to become differentiated. Such differentiation means that the groups and their members influence and are influenced by the group membership. If such differentiation is not taken into consideration, there are important risks associated with overlooking the importance of group effects (Goldstein 2011).

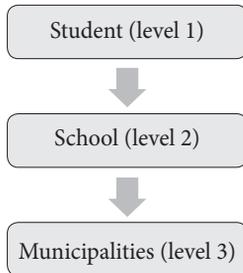
It is not uncommon to find research papers that use ordinary least squares (OLS) regressions to analyze datasets that are structured hierarchically. In such cases, violations of the necessary assumptions often take place when error terms are not independent but are instead clustered by one or more grouping variables. The clustering that occurs because of a grouping factor may lead to incorrect computations

of standard errors for prediction parameters, correlated error terms, and mistakes in interpreting the relative importance of the predictor variables. Miscalculating the standard errors may lead researchers to believe that there is a relationship when there is really none (Garson 2012). In such cases, the results may be spuriously significant.

Other researchers analyze hierarchical data by aggregating individual level observations to the group level and carrying out the statistical and econometric analysis at that level, in which case, the analysis would be done by performing regressions over group means. According to Steele (2008), this approach is problematic because standard errors of coefficients of group-level predictors may be severely underestimated. Additionally, there is no estimate of between-group variance. Furthermore, researchers cannot reach conclusions for the individual observations by using group (aggregated) regressions (Steele 2008).

Given the limitations of the estimation strategies outlined above and the structure of our dataset, we used a three-level multilevel model for the analysis (Diagram 1). In multilevel analysis the multilevel nature of data is taken into consideration when doing the statistical modeling by simultaneously modeling variables at different levels without resorting to aggregation or disaggregation of the dataset (Garson 2012). As Garson (2012) highlights, by aggregating and disaggregating data used in regression models there is a risk of running into an ecological fallacy —i.e. what is true at one level need not necessarily be true at another level. The advantage of using multilevel models is that these models handle data where observations are not independent, and by doing so, they are correctly modeling correlated errors. Additionally, it is possible to get an estimate of between-group variance. As Goldstein (2011) highlights, if neither students nor schools are modeled simultaneously, it is impossible to study the extent to which school and student characteristics interact to influence the response measurement or measurements.

Diagram 1. Three Level Multilevel Model



Source: Author's elaboration.

b. Instrumental Variables

It is also important to consider the possibility of endogeneity. It is credible to think that a student takes the intensity of conflict into consideration when deciding whether or not to continue studying. Some students may have special characteristics (i.e. support from parents) that better enable them to face conflict-related violence and to continue with their studies. To tackle this issue and in order to test the robustness of the results obtained using multilevel analysis, an instrumental variables approach is also considered. Following Camacho and Rodríguez (2013), we used instrumental variables in order to deal with the possibility of endogeneity as a source of bias. We used two instruments proposed by Camacho and Rodríguez to explain the presence of armed conflict in municipality m at time t : lagged laboratory dismantling ($z_{1t, t-1}$) and antinarcotics operations ($z_{2t, t-1}$). Specifically, we estimate the following reduced form equation in the first stage:

$$D_i = \pi_0 + \pi_1 z_{1t, t-1} + \pi_2 z_{2t, t-1} + \pi_3 F_i + \pi_4 S_i + \varepsilon_i \quad (2)$$

in which the intensity of the conflict is D_i explained by all the exogenous regressors.

Following Camacho and Rodríguez, we believe that these two instruments are valid for two main reasons. First, the dismantling of laboratories and the antinarcotics operations rate in municipality m at time t are highly correlated with armed conflict, suggesting that the instruments are relevant. The two instrumental variables are good measurements of governmental presence that is essentially geared towards offsetting the activities of illegal groups (Camacho and Rodríguez 2013). Our estimate of the first-stage equation shows that there is a significant negative relation between the two dissuasion techniques employed by the government and the intensity of the armed conflict. Second, there are very good reasons to believe that the two instruments are exogenous. It seems very unlikely that the schooling decisions of students today will be based on the two governmental deterrence decisions that are being used as instruments. As these authors highlight, antinarcotics operations and the dismantling of laboratories are normally secret operations that take place under conditions that are unknown to the civil population.

We used two different specifications in our empirical exercise. In the first specification we include all the control variables and we instrumentalize the intensity of the conflict in the year under analysis using the lagged measurement ($t-1$) of laboratory dismantling and antinarcotics operations. In the second specification we include all the control variables and we instrumentalize the intensity of the conflict in the year before the students took the national secondary school exit examination, using the lagged measure ($t-1$) of laboratory dismantling and antinarcotics operations.

6. Results

a. Multilevel Analysis Results

For the second semester of 2002 (Table 3), the overall mean score in mathematics (β_0) is estimated to be 42.008, and the variance 39.309. The variance can be decomposed into variance among municipalities (1.180), variance among schools (4.590) and variance among students (33.539). In terms of the VPC statistic, the results show that 3% of the variation in the mathematics test lies among municipalities, 11.7% lies among schools and 85.3% lies among students. In this case, the results obtained from the LR test also show that the three-level model is preferred to a single-level model ($\chi^2 = 42598.64, p < 0.000$), to the two-level students-within-municipality model ($\chi^2 = 28446.248, p < 0.001$) and the two-level students-within-schools model ($\chi^2 = 1034.263, p < 0.001$). Given these results, a three-level multilevel model should be used to analyze this dataset instead of a two-level or single-level model. For that same time period, in the case of the language exam dataset we can also justify the use of a three-level multilevel model. The overall mean score on the language exam (β_0) is estimated to be 47.029, and the total variance 45.993. The variance can be decomposed into variance among municipalities (2.091), variance among schools (7.812) and variance among students (36.090). The VPC statistic shows that 4.5% of the variation in the language test lies among municipalities, 16.9% among schools, and 78.6% among students. The LR test shows that for the language exam the three-level model is preferred to a single-level model ($\chi^2 = 63489.74, p < 0.000$), to a two-level students-within-municipality model ($\chi^2 = 42128.7, p < 0.001$) and to a two-level students-within-schools model ($\chi^2 = 1301.5, p < 0.001$). Given these results, the use of a three-level multilevel model is justified.

Table 3. Three-level Variance Components Model

Period 2002–2	Model 1 Mathematics	Model 2 Language
Parameter	Estimate	Estimate
β_0 Intercept	42.008	47.029
σ_{θ}^2 Municipality Variance	1.180	2.091
σ_u^2 School Variance	4.590	7.812
σ_e^2 Student Variance	33.539	36.090

Source: Author's calculations using data from ICFES, DANE and CERAC.

A Hausman-test was performed to see whether a random-effects estimation technique is appropriate. The results show that the null hypothesis cannot be rejected and, therefore, it is appropriate to use a random effects estimation technique. The results of this test further validate the use of multilevel analysis.

The results for mathematics (Table 4) show that the variable that indicates the intensity of conflict is not significant in any of the specifications considered. This is true for both the contemporary measurement of intensity and for the lagged measurements of intensity of conflict. Just as in the case of the mathematics examination, the results of the language examination show that the variable that indicates the intensity of conflict is not significant in any of the specifications considered. This is true for both the contemporary measurement of intensity and for the lagged measurements of intensity of conflict.³

Table 4. Random Intercept Model – Mathematics and Language Examinations

	Mathematics				Language			
2002-2	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intensity 2002	-0.025 (0.045)	-0.023 (0.046)	-0.033 (0.046)	-0.029 (0.046)	0.007 (0.048)	0.012 (0.048)	0.022 (0.049)	0.012 (0.048)
Intensity 2001		-0.003 (0.006)	-0.004 (0.007)			-0.008 (0.007)	-0.005 (0.007)	
Intensity 2000			0.003 (0.005)				0.006 (0.005)	
Intensity 1999			-0.008 (0.019)				-0.012 (0.021)	
Intensity 1998			0.019 (0.013)				-0.006 (0.014)	
Intensity 1997			-0.015 (0.014)				-0.024 (0.016)	
Average Intensity in Previous 5 Years				0.006 (0.013)				-0.013 (0.013)
-2*loglikelihood (deviance)	177841.4	177841.2	177840.6	177841.2	179498.9	179497.7	179496.4	179497.9
LR Test vs. Linear Regression (p-value)	Chi2(2) = 982.51 (0.000)	Chi2(2) = 979.70 (0.000)	Chi2(2) = 972.32 (0.000)	Chi2(2) = 974.46 (0.000)	Chi2(2) = 1272.35 (0.000)	Chi2(2) = 1273.36 (0.000)	Chi2(2) = 1273.48 (0.000)	Chi2(2) = 1272.56 (0.000)

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations using data from ICFES, DANE and CERAC.

3 The tables that contain the results with controls are available upon request.

In line with the results obtained using a random intercept model, the results obtained in the random coefficients model (Table 5) show that the variable that indicates the intensity of conflict is not significant in any of the specifications considered.⁴ This is true for both the contemporary measurement of intensity and for the lagged measurements of intensity of conflict. The results in the language examination also show that the variable that indicates the intensity of conflict is not significant in any of the specifications considered. This is true for both the contemporary measurement of intensity and for the lagged measurements of intensity of conflict.

Table 5. Random Coefficients Model – Mathematics and Language Examinations

	Mathematics				Language			
2002-2	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Intensity 2002	-0.025 (0.045)	-0.031 (0.047)	-0.042 (0.048)	-0.034 (0.048)	0.005 (0.056)	0.005 (0.056)	0.021 (0.056)	0.016 (0.051)
Intensity 2001		0.001 (0.004)	-0.006 (0.007)			0.001 (0.005)	-0.007 (0.008)	
Intensity 2000			0.002 (0.006)				0.006 (0.006)	
Intensity 1999			-0.003 (0.021)				-0.009 (0.024)	
Intensity 1998			0.021 (0.014)				-0.010 (0.017)	
Intensity 1997			-0.014 (0.014)				-0.020 (0.017)	
Average Intensity Previous 5 Years				-0.001 (0.016)				-0.022 (0.018)
-2*loglikelihood (deviance)	177841.4	177835.9	177825.0	177831.5	179494.4	179494.3	179490.1	179490.8
LR Test vs. Linear Regression (p-value)	Chi2(3) = 982.51 (0.000)	Chi2(4) = 986.85 (0.000)	Chi2(6) = 977.63 (0.000)	Chi2(4) = 984.17 (0.000)	Chi2(3) = 1276.85 (0.000)	Chi2(4) = 1276.89 (0.000)	Chi2(5) = 1271.77 (0.000)	Chi2(4) = 1280.13 (0.000)

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations using data from ICFES, DANE and CERAC.

⁴ The tables that contain the results with controls are available upon request.

b. Instrumental Variables Results

We evaluated both the relevance and validity of the instrumental variables. The fact that the instruments are not weak is confirmed with the Cragg-Donald F-test presented in Table 6. The F-statistic of the test of correlation among the instruments and the endogenous variable is 78.25 for the first model and 246.29 for the second model, overcoming the threshold of 10 that is usually considered acceptable (Staiger and Stock 1997). We also report the Kleibergen-Paap rank LM test as an additional test of instrument relevance under the null hypothesis that the instruments are uncorrelated with armed conflict. We used Hansen's J test as a test for over-identification. As reported in Table 6, the joint null hypothesis that the instruments are valid and that the excluded instruments are correctly excluded from the estimated equation is not rejected. This result gives us more confidence that the instruments are appropriate.

Table 6 shows the results of the instrumental variables approach used to quantify the impact of the intensity of the conflict on the results in the language and mathematics exit examinations.⁵ We tested two different specifications. In the first specification (model 1) we include all the control variables and we instrumentalise the intensity of the conflict in the year under analysis⁶ using the lagged measure ($t-1$) of laboratory dismantling and antinarcotics operations. In the second specification (model 2) we include all the control variables and we instrumentalise the intensity of the conflict in the year before the students took the national examination using the lagged measurement ($t-1$) of laboratory dismantling and antinarcotics operations.

Table 6. Instrumental Variables Approach

2002-2	Model 1 Language	Model 2 Language	Model 1 Mathematics	Model 2 Mathematics
Intensity 2002	-0.21* (0.126)		-0.032 (0.095)	
Intensity 2001		-0.155* (0.086)		-0.080 (0.060)
Observations	54279	54279	54279	54279
Cragg-Donald Wald F Statistic	78.25	246.29	78.25	246.29
Kleibergen Paap rank LM Statistic	17.37	10.09	17.35	10.09
Prob > F	0.0002	0.0029	0.0002	0.0029

5 The tables that contain the results with controls are available upon request.

6 The year in which the students took the national examination.

2002-2	Model 1 Language	Model 2 Language	Model 1 Mathematics	Model 2 Mathematics
Hansen's J Statistic	2.555	0.111	1.497	0.032
P-value	0.1099	0.7393	0.2212	0.8571
Instruments: lagged laboratory dismantling and antinarcotics operations				

Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note: All specifications include student, school, and municipal controls.

Source: Author's calculations using data from ICFES, DANE and CERAC.

The results show that there is a negative and significant effect of the intensity of the conflict on student performance on the language examination in both of the specifications considered. It should be highlighted that the results obtained using the hierarchical model (random coefficient model) showed results that differ from those obtained using the instrumental variables approach. The results using the random coefficient model showed that there was no significant effect of the intensity of the conflict on the results in the language examination. In the case of the mathematics exit examination, the results do not show a significant effect of the intensity of the conflict in the two specifications considered for the analysis. In this case, the results are similar to the results obtained using the hierarchical model (random coefficient). The results obtained using these two methodologies show that the variable indicating the intensity of the conflict is not significant under any of the specifications considered. It should also be highlighted that in the results obtained using the two methodologies the coefficients for the intensity variable are very similar.

7. Discussion of the Results

The research results presented in this paper show that the relationship between the intensity of the conflict and student performance on exit examinations is not as straightforward as it may seem at first glance. The results obtained using a multilevel model do not show any significant relation between civil conflict and educational achievement, whereas the results obtained using an instrumental variables approach do provide evidence of the negative repercussions that a civil conflict can have on the educational achievement of students. However, it is particularly important to highlight the fact that the results show a smaller than expected effect. There are two reasons why we believe this is so: i) the protective role of education and ii) a self-selection mechanism.

The findings of this research may be indicative of the protective effect that can result from attending school. Indeed, the literature has shown that attending

school can play a very important role in protecting vulnerable children and young adults. It is well known that children and young adults who live in conflict zones are vulnerable and in need of special protection. Schools can deliver that protection by providing them with a safe place to play, offering an alternative to destructive conduct, providing access to healthy and nutritious meals, and offering guidance from counselors and teachers. Nicolai and Triplehorn (2003) have pointed out that education benefits the psychosocial health of students living in conflict zones. That is because attending school provides students with an opportunity for self-expression and interaction with other children. This interaction is particularly important because it boosts their sense of identity and inclusion. Keeping youngsters in school can serve as a protective mechanism because it gives students a sense of self-worth, enables them to develop social networks, and provides a structured program of activities (Nicolai and Triplehorn 2003). Additionally, as Smith (2010) highlights, schools provide critical information and develop problem-solving skills that can help protect students from exploitation and harm such as abduction and child soldiering.

Sommers (2002) has highlighted that despite the traumas caused by civil war, some children do manage to become healthy, vibrant, contributing adults. Said researcher points out that it is possible to foster resilience amongst children and young adults who have been affected by the civil conflict (Sommers 2002). Attending school is crucial because it can help youngsters regain hope by providing them with better prospects for the future. Nicolai and Triplehorn (2003) highlight the fact that by setting goals such as completing homework, preparing for exams, completing a school certificate, regular assignments and tests, schools can provide students with achievable objectives that can be seen as reasons to continue fighting for a better future. In fact, Gomez (2016) has highlighted the important role of resilience in explaining the better than expected academic outcomes of Colombian students who have been affected by civil conflict. Education indeed plays a critical role in building bridges and in helping to break down stigma.

Education is fundamental in order to achieve stability in countries that are being affected by a civil conflict. In fact, as Justino has highlighted:

“[...] education systems in conflict-affected countries can play important roles in supporting stability and economic resilience when children and young people are educated or trained to support positive social change, and when they work in tandem with interventions aimed at addressing specific poverty, vulnerabilities and aspirations of individuals and households affected by violence.” (2014, 12)

Furthermore, it is particularly important to understand that in countries like Colombia where peace processes are underway, education can play a vital role by contributing to the transformation of the conflict (Smith 2014). This can be done by educating people about potential new arrangements for political representation and justice that can reduce confrontation between different groups within society.

Self-selection is a second factor that may explain why the results obtained in this research show a smaller-than-expected influence of conflict on achievement in standardized examinations. It is important to emphasize that the empirical studies presented in this paper concentrate only on those students residing in conflict and non-conflict zones who take part in the formal education system. These students are the ones who are evaluated in the exit examinations, and therefore, they are the ones that we can observe in the micro data. However, it is possible that those individuals who are more affected by conflict do not participate in the formal education system, and therefore they are not observable in our dataset. In fact, the literature has shown that those individuals who do not have the resources (monetary, psychological, family support) to overcome or adapt to the rough conditions that are prevalent in conflict areas are more likely to drop out of the formal educational system. In that sense, self-selection could also explain our results because it is more likely that those individuals with the resources to overcome or adapt to the harsh conditions will have the opportunity to continue with their studies.

For the Colombian case, there are a number of studies that have documented the relationship between civil conflict, low levels of enrolment, and dropping out of school. Rodríguez and Sánchez (2012) have found that armed conflict reduces the average number of years of schooling by 8.78% for a pooled sample of Colombian children, and it reduces the average years of schooling by 17.03% for those between 16 and 17 years of age. Barrera and Ibañez (2004) have also found that after controlling for individual, household and other context variables, violence negatively influences school enrolment. Furthermore, Sánchez and Díaz (2005) show that municipalities affected by the activities of illegal armed groups had slower growth rates of primary and secondary school enrolment compared to municipalities that were not affected by illegal activities, when a matching mechanism is used. Wharton and Oyelere (2011) also show that children who live in a municipality with high levels of conflict have a gap in enrolment and accumulation of schooling.

The evidence presented in this article can be used to guide the formulation of educational policy. Targeted policies should be implemented in order to provide special support for the students who remain in conflict areas so they can continue their studies. There are a number of policy recommendations that

could be implemented to guarantee that those students who remain in conflict zones will have the adequate incentives and resources to continue their studies. As Winthrop and Kirk (2008) highlight, students who live in a country affected by civil conflict are more likely to be heterogeneous in terms of age, social background, competence, family responsibilities, and previous educational opportunities. Given these heterogeneities, and in order to formulate targeted policies, governments should prioritize the implementation of a baseline assessment, and local leaders who have information on population movements should play a central role in this tracking process (Hillesund *et al.* 2014).

Winthrop and Kirk (2008) point out that psychosocial intervention in educational settings can help improve the potential of children affected by conflict. In that respect, the Colombian government should offer special psychological support for families and communities to help children cope with the stress and trauma caused by the civil conflict. It is also very important to identify the specialists who can address the psychosocial needs of children and young adults, as such interventions can help students cope with the trauma of educational disruption (Chand *et al.* 2003).

According to Hillesund *et al.* (2014), school participation levels depend more on reduced cost of access than on improved quality of education. Furthermore, these authors have shown that vulnerable households respond well to reduction in access costs (Hillesund *et al.* 2014). There are a number of policy instruments that could be implemented in order to reduce direct and indirect costs. One possibility is the implementation of a voucher system. School vouchers are government-funded scholarships that pay for students to attend school, either public or private. These vouchers allow students to attend the school of their choice. A second mechanism that could be considered is conditional cash-transfer (CCT) programs. In a conditional cash-transfer program, the government transfers money to vulnerable households that meet certain conditions.

Policy makers should also work to create new and better incentives for students who reside in conflict zones to remain in school with full-time dedication and, if possible, to provide financial assistance so that qualified students have the opportunity to attend university. The design of such policies is a crucial task that should be prioritized on the agenda of Colombian policy makers. More governmental resources should be spent in order to meet the special needs of students who have been affected by conflict (i.e. psychological help, school supplies, special remedial tutorials) and to supervise their progress in educational institutions. The government and development agencies should provide funding in order to assure that schools in conflict zones provide high-quality education that is also inclusive. Low levels of investment in education for young adults who are in danger can make peace more difficult to achieve.

It should be noted that all these efforts not only help improve the quality of life of the individuals affected by the conflict. Østby (2013) has highlighted, there is evidence that clearly points to a pacifying effect of education, which has positive repercussions for the entire society. Furthermore, Østby has also emphasized that democracies like Colombia tend to experience a greater stabilizing effect of education than non-democracies do.

Special efforts should be made in conflict zones to strengthen the capacity of educational authorities and to promote the organizational development of schools. Additionally, policy makers should design policies to develop the different factors that are conducive to effective schools (i.e. shared vision and goals, a learning environment, concentration on teaching and learning, purposeful teaching, high expectations, home-school partnership, and learning organization). Policy makers should design effective policies to guarantee that the schools in conflict zones have sufficient incentives and resources to continue developing these factors. It is particularly important to provide sufficient training for teachers and school authorities on how to deal with the special circumstances associated with the conflict. For instance, teachers should be prepared to guide students that need special protection (e.g. those who are displaced or at risk of recruitment).

Public authorities should also make the necessary arrangements to protect schools. This is particularly important in order to guarantee that schools are safe learning spaces where students can feel protected. Authorities should also monitor school attendance. This is particularly important in order to have an early detection system of those students who are more likely to drop out of school. As mentioned previously, the students who drop out of the formal education system may be the ones that are most seriously affected. The authorities should implement programs to assist families (i.e. employment programs, conditional cash-transfer programs and other forms of subsidies) in order to reduce some of the needs and vulnerabilities associated with the civil conflict that affect the well-being of school-aged individuals.

Concluding Remarks

This paper explores the relationship between civil conflict and educational achievement in Colombia through the use of multilevel analysis and an instrumental variables approach. The findings presented here will contribute to the existing literature regarding the impact of civil conflict on education. Multilevel analysis was employed in the study in order to deal adequately with the hierarchical structure of the data by simultaneously modeling variables at different levels without resorting to aggregation or disaggregation of the dataset. We also used an instrumental variables approach to tackle the possibility of bias associated with endogeneity.

The results obtained show that the relationship between the intensity of the conflict and student performance on exit examinations is not as straightforward as it would seem at first glance. The evidence presented can be used to guide the formulation of educational policy. In particular, it can provide insights for policy makers who are interested in the formulation of educational policy for conflict and post-conflict scenarios. There are a number of policy recommendations that can be derived from this research and implemented in order to ensure that education plays a protective role in conflict regions. Policy makers should design policies to provide special support for the students who remain in conflict areas so that they can continue their studies. It is possible that the students who are facing difficulties associated with the armed conflict are also developing high levels of resilience that enable them to continue their studies, but they need a special follow up. The implementation of the policies suggested in this article can play a central role in guaranteeing that those students who remain in conflict zones have the necessary incentives and resources to continue their studies. This is particularly important because by keeping youngsters in school it becomes possible to improve the levels of accumulation of human capital in the areas of the country that have been particularly affected by the civil conflict, so that these individuals can have better opportunities in the future.

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