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Armed conflict and academic performance. A spatial approach for Colombia

John Ariza[1] · **Juan Pablo Saldarriaga**[1]

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Abstract

This paper studies the incidence of the Colombian armed conflict on the academic performance of secondary students at the municipal level for the years 2003 and 2017. By using a General Nesting Spatial model, results suggest the conflict negatively affects academic performance. In 2003, a period of high conflict intensity, terrorist population attacks showed both direct and indirect negative effects on the test scores. In 2017, a period of low intensity, only direct negative effects were reported for the variables of forced displaced people, homicides, and victims of threat.

Keywords Armed conflict · Academic performance · Education · War

Introduction

Worldwide armed conflicts have had devastating economic and social impacts on the population, especially affecting young people. According to UNESCO (2011), war not only ends human lives, but also reduces means of livelihood, increases health risks, decreases economic growth, and diverts public resources from social spending to military spending. Children living in conflict-affected areas are twice as likely to be out of school, and young people are 70% more likely to be out of school than those living in other areas (UNESCO, 2015).

Armed conflicts affect academic performance in different ways. It forces the modification of school calendars and thematic contents of institutions, deteriorates physical infrastructure, and restricts access to educational resources for learning. It generates risk and uncertainty in families and students and can also violate and intimidate teachers, among many others. Although Colombia has one of the oldest armed conflicts in Latin America, the literature that addresses the impact of the armed conflict on the quality of education in

✉ Juan Pablo Saldarriaga
jpsaldarriagam@ut.edu.co

John Ariza
jfariza@ut.edu.co

[1] Universidad del Tolima, Barrio Santa Helena Parte Alta Cl 42 1-02, Ibagué, Colombia

this country is recent. In 2016, the Colombian government of Juan Manuel Santos signed a peace agreement with the most important subversive group FARC-EP, and little evidence on its incidence on educational variables has been provided.

Given that historically, the activity of subversive groups has been concentrated in key territories of the country (associated initially with drug trafficking), and given that such groups have different size, composition, and territorial influence, a methodological study of the effects of armed conflict on educational variables should use a spatial approach. This is because the armed conflict not only affects people living in the zones where the violent groups are based, but it also affects the people living near these zones by 'neighborhood effects.' For example, armed conflicts generate forced displacement that changes the features of cohort students of other municipalities. It is important to note that the type of violence created by groups outside law is different depending if they are more rural or urban.

This paper contributes to the literature by estimating the direct and indirect incidence of armed conflicts on academic performance over two time periods that have different conflict intensity levels. A General Nesting Spatial-type econometric model of spatial lags will be estimated to identify the direct spatial effects (intensity of the armed conflict on the municipality itself) and indirect effects (intensity of the armed conflict in neighboring towns) on the academic performance of the municipality.

In section two, the paper presents a literature review of the empirical evidence on armed conflict and academic performance. In section three, it presents the theoretical framework used. In section four, it explains the methodology and the data source used. Results are presented in section five. Finally, section six provides some concluding remarks.

Literature review

There are multiple mechanisms through which armed conflicts affect academic performance. Some of the most important are: damage to the physical infrastructure of schools that limits or makes providing educational services impossible, psychological effects on children that negatively impact their learning process, and an increase in desertion because of parents' fear of sending their children to school. In the first case, and according to Sommers (2002), during armed conflicts, schools will not only be poorly endowed and disconnected from national policies, but their teachers will face adverse conditions that will reduce their performance and affect educational quality.

In the second case, exposing children to situations of forced displacement, death of people in their community, and/or abandoning their home due to murder or recruitment generates violent practices and behaviors in the children themselves that hinder the learning processes (Ramos & Miranda, 2012). These students tend to present behaviors typical of victims of violent events such as depression, isolation, aggressiveness, intolerance, and learning difficulties (Osorio, 2016). Forced displacement in children does not allow, for example, the development of a life project. This phenomenon can subsequently generate homelessness and illegality in young people (Gamboa et al., 2019).

In the third case, fear affects educational results because it produces insecurity when enrolling children in schools due to the risk of violent attacks (Justino, 2011).

Schools, teachers, students, and staff are often targets of attack. In general, armed conflicts increase the fear of children to attend classes, of teachers to teach them, and of parents to send their children to school. This, in turn, causes school dropouts to increase (Davies, 2004; Naciones Unidas, 2010; Velásquez & García, 2018).

There is much international empirical evidence that reports negative effects of war, conflict, and violence on educational variables in several countries. In the case of war, Akresh & Walque (2008) studied the impact of the genocide in Rwanda in 1994 and concluded that the average years of schooling fell in one year. Likewise, Chamarbagwala & Morán (2010) found that the civil war in Guatemala reduced the average years of schooling by 30% in women and 20% in men. Parlow (2011) showed that during the 90's, the insurgency in Cachemira (India) decreased the general enrollment rate and it affected more girls than boys.

In the case of conflict and violence, Monteiro & Rocha (2013) found that in Brazil, exposing students at the primary level to crime caused by drug gangs near educational institutions reduced mathematics test scores. Similarly, Orraca (2018) showed in Mexico, exposing primary and secondary students to crime reduced test scores in reading and mathematics and increased the probability of losing the academic year. In Israel, Shany (2018) stated that a terrorist attack reduced the score of the final test in secondary schools. The effect was greater as the number of deaths increased and the distance of the attack decreased. Brück et al. (2019) reported that in Palestine, conflict not only reduced the probability of passing a final exam but also reduced the probability of being admitted to a university.

Empirical evidence in Colombia suggests that armed conflicts have a negative relationship with academic performance at different levels of training and under different methodological approaches. The studies that have addressed the issue are presented below, using state test scores as the dependent variable and different measures of the presence and intensity of the armed conflict as explanatory variables. For example, terrorist events, number of massacres, actions by armed groups, accidents caused by antipersonnel mines, displaced persons, and demobilization of armed groups, among others.

In the works of Munévar et al. (2019), Quintero et al. (2016), and Miranda et al. (2015), Munévar et al. (2019) used variables of the intensity of the armed conflict such as armed actions, massacres, and displaced persons. These studies use a multinomial logistic model and conclude that the increase in armed attacks in a municipality in 2016 could have generated a higher proportion of students with an insufficient level in the Saber 3, 6, 9, and 11 tests. Taking into account a group of close departments, Quintero et al. (2016) and Miranda et al. (2015) report, based on linear regressions, that the intensity of the armed conflict for the period 2005–2006 may have generated a lower performance in the area of citizenship competencies for grades eleven and nine. In the same way, Gómez (2016), using a pseudo panel for the years 2000, 2002, 2005, and 2007, concluded that there is a negative relationship between civil conflict and the academic performance of 11^{th} grade students.

Rodríguez & Sánchez (2010) approached the estimation of the causal effect through an explanatory variable, exposure to conflict. According to this research, during the period 1996 – 2003, there was an increase in the standard deviation in the measure of the armed conflict in Colombia. This caused a decrease of 0.74 standard deviations in test scores. Similarly, the study by Gómez (2017), based on a multilevel analysis

and an instrumental variable approach with variables of presence and intensity of conflict, concludes that, in the latter case, there is a negative and significant relationship between academic performance and the presence of an armed conflict. However, the result obtained from the multilevel analysis suggests that the relationship between the variables is not as simple as it first seems.

Using the demobilization of paramilitary blocks during the period 2003 – 2006 as a conflict variable and based on a differences-in-differences methodology, Díaz (2019) concluded that the demobilization of these paramilitary groups had positive and differentiated effects at the municipality level on the average weighted Saber 11 test scores. In particular, the demobilization of the Peasant Self-Defense Forces of Córdoba and Urabá (ACCU) had a lesser effect compared to the rest of the municipalities, since at that time other groups were being consolidated in the region. For the case of Medellín, Haugan (2016) estimates the effect of urban violence on student achievement in the city from a model that includes school and year fixed effects, concluding that for each additional homicide occurred in a range of 500 m around a certain school, student performance decreases by 0.01 standard deviations.

Studies that use the spatial econometric approach to analyze the armed conflict and academic performance are very scarce in the literature. Instead, existing studies analyze the relationship between armed conflicts and other variables. For example, Sánchez et al. (2003) analyzed the relationship between armed conflicts and manifestations of violence with a panel-type spatial econometric model. Their results suggest that there is evidence of persistence and spatial diffusion in all crimes. Chacón (2004) uses autoregressive spatial models to analyze the municipal characteristics that determined the presence and intensity of violence in Colombia. Their results suggest that the presence of municipal violence depends in turn on violence in neighboring municipalities, generating spatial diffusion and contagion effects.

According to these, an analysis of the relationship between the armed conflict and academic performance in Colombia from a spatial perspective is key from a theoretical point of view and is novel from an applied point of view. Sharma & Gibson (2019) argue that ignoring indirect spatial effects can affect the results since people living in conflict are even more affected by close conflicts. At present, there are, to our knowledge, no studies for the Colombian case that address this issue under this approach.

As shown by the literature review, existing studies use linear regressions and, in some cases, instrumental variable methods, differences in differences, multilevel models, panels, and pseudo panels. The incorporation of neighborhood effects into the analysis enriches the understanding of how the armed conflict has affected the academic performance of students in Colombia. That is precisely the objective of the present work and constitutes the main contribution to literature.

Educational production function and armed conflict

From a theoretical point of view, this article considers the concept of an educational production function proposed by Hanushek (1979) as a starting point, expanding it to include a spatial dimension in the analysis. In principle, the educational production function posits that educational achievement at the individual level is a function

of a set of inputs related to the personal characteristics (observable and unobservable) of the student, their family and social environment, and the characteristics of the educational institution. However, given that, in the context of this study, the unit of analysis is the municipality, the educational production function is extended to this scale to evaluate the direct and indirect spatial effects associated with the armed conflict and the other explanatory variables of performance.

In accordance with the above, the variable to explain is the municipal average of the standardized test scores. This average is a function of both internal and external municipal inputs. Internal inputs include the budget allocated to education, the characteristics of the educational institutions, the characteristics of the socioeconomic environment, and the level of armed conflict within the municipality, among others. External inputs mainly involve the level of influence the conflict occurring in the municipalities' neighbors has on the average score of the municipality in question. These external factors incorporate the concept of spatial dependency on the function of educational production and are of interest in the present investigation.

Internally, the intensity of the conflict variables could be measured by the following factors: the number of terrorist attacks, the number of victims of homicides by illegal groups, the number of victims of threats from these groups, and the number of people displaced by the conflict. In each case, there is a direct negative relationship between the level of conflict and the impact on academic performance due to the effects that each of them has not only on students, teachers and parents, but also on infrastructure and material conditions under which the teaching process was developed. Although it is expected that there will be, in general, a negative incidence of the conflict, the magnitude of the effects may be different to the extent that the mechanisms of transmission of the effects are heterogeneous.

Terrorist attacks deteriorate a municipality's infrastructure and can suspend school activities and generate uncertainty in teachers and parents, as explained in the literature review. Murders and threats by armed groups generate uncertainty and fear in the population. Finally, forced displacement has psychological effects on students that affect their academic performance to the extent that it alters their family structure, the economic conditions under which they live, and the social environment with which they relate. At the municipal level, displacement changes the composition of school groups in both the sending and receiving municipalities.

Variables such as the student–teacher ratio, real budget spending on education, tax revenues, and the rurality index can also be considered as internal factors of the municipalities. These variables are generally associated with the quality of education and with the economic activity and social composition of the municipality. In this way, a positive relationship is expected between real spending on education and the volume of tax revenue, while a negative relationship is expected between the ratio of students per teacher and the greater rurality of the municipality.

For external factors, and according to Tobler's law (1979) in which 'all things are related to each other but the closest things have a greater relationship than the furthest', we consider the influence that the socioeconomic and armed conflict characteristics of the neighboring municipalities can have on the municipality in question. All the previously mentioned explanatory variables of neighboring municipalities are incorporated into the model as external factors. The results of a municipality's teaching process may

be affected negatively, indirectly, and on a different scale by terrorist attacks, homicides, threats and displacements that take place in neighboring territories.

This work considers two periods of analysis with different dynamics and armed conflict intensities. 2003 was considered a period of high intensity conflict in which 24.1 victims of homicides by these groups and 227.8 displaced persons both per 10,000 inhabitants were reported. Contrastingly, the period 2017 after the peace agreement with the main guerrilla group in the country contained 0.6 victims of homicides and 41.6 displaced per 10,000 inhabitants reported. The interpretation of the results of the spatial techniques in these two time periods will be based on this theoretical framework.

Methodology and data

Methodology

Given that the armed conflict is not randomly distributed throughout territory as well as it can generate potential spillover effects, Exploratory Spatial Data Analysis (ESDA) techniques are used. Both choropleth mapping and calculation of the global and the local spatial autocorrelation measures are used to study the spatial distributions and the spatial patterns of the variables of interest. Spatial autocorrelation occurs when similar values or dissimilar values for a random variable tend to be clustered in space (Anselin, 1995).

For the global case, we use the global Moran´s I index (Moran, 1948) that formally is given by:

$$\mathrm{I} = \frac{n \sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i \sum_j w_{ij} \sum_i (x_i - \bar{x})^2}$$

where n represents the number of municipalities; x are the values of the variable of interest with i as spatial unit under study and j the neighbor spatial unit of i; w_{ij} is the spatial weighted matrix that assigns 1 to the all the neighbors of unit i and 0 otherwise. Moran's index ranges over the interval [-1, 1] with 0 indicating no autocorrelation. We also consider the bivariate Moran´s index to study spatial correlation between academic performance and armed conflict variables.

For the case of local indicators, we use the Local Indicators of Spatial Association (LISA) proposed by Anselin (1995) that use the Local Moran´s index to evaluate the statistical significance of the existence of clusters. The maps from LISA shows four types of spatial clustering: high-high (H–H), low-low (L-L), high-low (H–L) and low–high (L–H) with a significance level of 0.05.

Regarding spatial econometrics, this research implements a model that considers the direct and indirect effects of the armed conflict on the academic performance of

students at the municipal level. The starting point is a basic spatial lag model called the first order spatial autoregressive model (SAR), which is presented in Eq. (1).

$$Y_i = \rho \sum_{j=1}^{n} W_{ij} Y_j + \sum_{q=1}^{Q} X_{iq} \beta_q + \varepsilon_i \qquad i = 1, ..., n \tag{1}$$

where the dependent variable Y_i (academic performance in municipality i) is a function of its own spatial lag Y_j with W defined as a spatial weight matrix that assigns the value of 1 to the neighbors of each territorial entity and the value of 0 to those who do not meet this condition, a set of Q explanatory variables including the intensity of the armed conflict X_{iq}, and an independent and identically distributed error term (ε_i). The scalar ρ indicates the degree of spatial correlation between the value of the academic performance (Y) of a town i with the performance of the other neighboring towns. In matrix terms the SAR model can be denoted as in Eq. (2):

$$\boldsymbol{Y} = \rho W \boldsymbol{Y} + \boldsymbol{X}\beta + \varepsilon \tag{2}$$

However, in the context of the present study, spatial dependence influences not only the dependent variable through its lags and the explanatory variables but also the error term. A General Nesting Spatial (GNS) model considers these characteristics and incorporates spatially lagged explanatory variables and spatially lagged error terms that can be expressed in matrix terms as in Eq. (3):

$$\boldsymbol{Y} = \rho W \boldsymbol{Y} + \boldsymbol{X}\beta + W\boldsymbol{X}\gamma + \lambda W \boldsymbol{u} + \varepsilon \tag{3}$$

In this case, β reflects the direct effects of the explanatory variables on the academic performance of the municipality, while γ reflects the marginal impact of the explanatory variables of the neighboring municipalities on academic performance. This last term includes the indirect effects of the armed conflict existing in neighboring municipalities, on the level of academic performance of a municipality under consideration.

According to Elhorst (2010) and in order to evaluate the proposed specification of the econometric model in cross section data, we estimate the family of models SAR (Spatial Autoregressive Model), SEM (Spatial Error Model), SAC (Spatial Autoregressive Combined Model), SDM (Spatial Durbin Model), and GNS and test the statistical significance of the ρ and λ terms. Cross sectional data is used in this paper because some of the variables are not consistently observed over time to apply a panel data approach.

Data sources

The data in this paper come from two sources. First, we use the ICFES state test database for grade 11 in 2003 and 2017. This database contains information on academic performance, the dependent variable of the model, and it is standardized for purposes of the econometric estimation. The state test is applied in person two times per year to students in the last grade of the upper secondary level to evaluate competencies in reading, mathematics, science, and English language. The test score is used to enter higher education. In terms of educational policies and procedures at the primary and secondary

education levels, the relevant administrative units are the secretaries of education. If the municipality is certified by the government, it can manage educational activities directly. If not, the states (departments that groups municipalities) manage such activities. Second, we use the CEDE municipal panel of the Universidad de los Andes that provides information on general characteristics, health, education, conflict, and violence of the municipalities in Colombia during the same periods.

The following measures the intensity of the armed conflict variable: terrorist attacks, victims of homicides, victims of threats, and victims of forced displacement, suggested by Restrepo et al. (2004), Gomez (2017), Haugan (2016), Orraca (2018), and Sharkey (2010). These measures allow different mechanisms to evaluate how the conflict can affect academic performance.

Separate regressions of Eq. (3) are calculated for each time period 2003 and 2017. Control variables containing economic structure, geographical characteristics, investment in education, and the ratio of students-to-teacher are included at the municipal level. Table 1 presents the variables used in the model and their data sources.

Results

Descriptive statistics

Table 2 shows the descriptive statistics of the variables of the econometric model for the years 2003 and 2017. According to the table, the average score of the state test for 2003 was 50.18, while for 2017 the average fell to 47.41. This decreased in mean score is accompanied by a higher standard deviation suggesting a more heterogeneous performance in aggregate terms. Regarding the intensity of the armed conflict, populations are affected mainly by the forced migration and in lesser degree by homicides, threats, and terrorism attacks. In 2003 the number of displaced people per 10,000 inhabitants was about 227 while the victims of terrorism attacks were about 1.3 per 10.000 inhabitants. The mean and median of the conflict variables show an asymmetric distribution along territories.

Over the time periods considered, all measures of the conflict reduced with significant decreases in displaced people (a reduction from 227.8 to 41.6 per 10.000 inhabitants) and victims of homicides (reduced from 24.1 to 0.59 per 10.000 inhabitants). Results for terrorist attacks are consistent with the timing of the de-escalation of the conflict with the main subversive group (FARC-EP) that used this tactic to seed fear. In the same time periods, the control variables show a decrease in investment in education as well as the number of students per teacher, and an increase in the municipality tax revenues and a drop in rurality index scores indicating that municipalities are more urban.

Exploratory spatial data analysis

In Table 3, we present the univariate Moran´s index for the variables of interest in the two years selected. According to the table, academic performance in the upper secondary level

Table 1 Variables of the econometric model

Variables	Description	Source
Dependent		
Academic performance	State test scores in grade 11 at the municipal level Results presented as standardized scores	ICFES
Explanatory		
Armed conflict	Presence of the armed conflict Terrorist attacks perpetrated by illegal groups Value = 1 if the town registered at least one attack Value = 0 if it did not register any attack	CEDE
	Homicide victims Number of victims in homicides committed by illegal groups per 10,000 inhabitants	Unidad de víctimas/ CEDE
	Displaced victims Number of displaced people caused by illegal groups per 10,000 inhabitants	Unidad de víctimas/ CEDE
	Victims of threats Number of victims of threats caused by illegal groups per 10,000 inhabitants	Unidad de víctimas/ CEDE
	Victims of attacks Number of victims in attacks caused by illegal groups per 10,000 inhabitants	Unidad de víctimas/ CEDE
Students/ teachers	Number of 11th grade students taking the Saber 11 state tests per number of middle school teachers	DANE / Icfes
Education investment	Investment in education per student who took the Saber 11 test, measured in millions of pesos at constant 2008 prices	CEDE/ Banco de la República
Capital of the department	Dichotomous variable value = 1 if the municipality is the capital of the department and 0 otherwise	CEDE
Tax income	Per capita tax income, measured in millions of pesos at constant 2008 prices	CEDE/ Banco de la República
Rurality index	Percentage of population in rural area of the municipality	CEDE

Table 2 Descriptive statistics of the variables

Variable	Year	Mean	Std. Dev	Median	Min	Max	Obs
Icfes Score	2003	50.1	2.1	50.6	39.5	57.0	1,019
	2017	47.4	3.3	47.6	36.3	55.9	1,119
Victims of homicide	2003	24.1	34.7	13.4	0	362.2	1,118
	2017	0.59	2.157	0.00	0	21.4	1,119
Victims of forced displacement	2003	227.8	527.9	64.7	0	362.2	1,118
	2017	41.6	133.0	8.5	0	2094.5	1,119
Victims of attacks	2003	1.36	9.5	0.0	0	280.0	1,118
	2017	0.0	0.0	0.0	0	52.3	1,119
Victims of threads	2003	8.4	23.0	2.1	0	334.4	1,118
	2017	7.8	14.8	1.8	0	198.9	1,119
Investment on education	2003	5.4	7.3	3.3	0	131.4	1,085
	2017	2.9	2.374	2.48	0	47.7	1,108
Tax incomes	2003	0.05	0.06	0.03	0.000	0.6	1,097
	2017	0.16	0.21	0.10	0.001	2.9	1,098
Rurality index	2003	0.59	0.23	0.64	0.002	1.0	1,118
	2017	0.55	0.24	0.58	0.001	1.0	1,119
Students per teacher	2003	11.9	12.8	8.59	0.42	189	998
	2017	10.2	5.07	9.25	1.75	52	1,088

Authors' calculation based on data from ICFES, DANE, CEDE, Unidad de Victimas and Banco de la República

is highly correlated among municipalities in the country. It presents an index of spatial autocorrelation in 2003 about 0.65 that remains high despite decreases during the period. This spatial pattern is in line with Galvis (2015) who suggests that geographically, higher scores are located in the areas of the Andes mountain range; median scores are located in the areas of Caribbean coast; and lower scores are located in the Pacific, Orinoquia, and Amazon regions. Such a spatial pattern is consistent with the level of economic and social development of the regions.

Regarding armed conflict variables, spatial autocorrelation measures suggest that in 2003 victims of homicides exhibit the highest index followed by forced displacement, victims of threats, and terrorism attacks. By 2017, spatial autocorrelation indexes increase more for victims of threats, followed by forced displacement and terrorist attacks, and

Table 3 Univariate Moran´s I

Variable	2003	2017
Icfes score	0.654	0.585
Victims of homicides	0.360	0.188
Forced displacement	0.259	0.312
Terrorism attacks	0.026	0.139
Victims of threats	0.124	0.527

Authors' calculation based on data from ICFES, DANE, CEDE, Unidad de Victimas and Banco de la República

decrease for victims of homicides. This pattern may be related to the characteristics of the conflict, indicating that the degree of spatial association for homicides is lower due to the reduction of the traditional area of influence of groups outside the law. It is higher in other cases with the characteristic that for threats, they could be more selective, and the victims could be associated with other types of structures and criminal organizations.

Prieto et al, (2014) suggest that due to the different policies and strategies implemented by the government, these groups were weakened and had to reduce their margin of action to implement less intensive activities in human capital (placement of explosive devices such as mines, anti-personnel weapons, and the use of snipers), and the subsequent abandonment of territories where their presence was historical, retreating to strategic territories for their defense and supply routes.

In Table 4 we present the bivariate spatial autocorrelation between academic performance and the four measures of armed conflict. According to the results, bivariate spatial autocorrelation indexes were negative and very low in 2003. However, by 2017, all bivariate measures became larger, some more than others. For example, Moran's index of victims of threats went (in absolute values) from 0.012 to 0.321. This result is interesting insofar as it captures different features of the relationship between armed conflict and academic performance.

By using different measures of conflict intensity, this work implicitly considers different transmission mechanisms through which conflict affects student performance. It would be expected that the degree of autocorrelation would be greater to the extent that the displaced have a higher incidence on the number of students and their academics at the municipal level, while threats can translate directly into desertion not only of students but also of teachers fleeing from war.

Given that the bivariate Moran's index between academic performance and victims of threats showed a higher increase during the period, Fig. 1 presents clusters maps from LISA. The maps present the location and evolution of clusters of regions with high academic performance and low victims of threats (pink color) and regions with low academic performance and high victims of threats (blue color). The left panel shows LISA indicators for 2003 while the right one shows LISA indicators for 2017. According to the results, by 2003 the regions of Cundinamarca, Boyacá, and Santander are in the first group while some few regions of Caribbean coast, Nariño, and Putumayo are in the second.

By 2017, there were important changes in the extension and distribution of these areas in the country. Clusters of high academic performance and low conflict intensity appear mainly in the same region (Cundinamarca, Boyacá, and Santander) while

Table 4 Bivariate Moran´s I

Variable	2003 Icfes score	2017 Icfes score
Victims of homicides	-0.018	-0.151
Forced displacement	-0.011	-0.257
Terrorism attacks	-0.034	-0.064
Victims of threats	-0.012	-0.321

Authors' calculation based on data from ICFES, DANE, CEDE, Unidad de Victimas and Banco de la República

clusters with low academic performance and high conflict intensity appear in new areas and to a higher extent, forming agglomerations not only in the Pacific coast but also in the departments of Putumayo, Caquetá, Guaviare, and Meta. This spatial pattern is consistent with the retreating of the armed groups outside the law to strategic territories for their defense and supply and drug trafficking routes.

Econometric results

In order to test if the General Nesteing Spatial framework is the most appropriate functional form to model the spatial relationship between variables, Table 5 presents SAR, SEM, SAC, SDM and GNS model specifications and related results according to Elhorst (2010). Direct and indirect effects are shown as well as the statistical significance of terms ρ and λ for all measures of armed conflict for 2003 and 2017 using a spatial weighted matrix of the first order neighbors. Results for the 1st- and 2nd-order neighbors are presented in Appendix 1 Table 7 and suggest that the general results remain. According to the estimations, ρ and λ are statistically significant implying that the appropriate model in this case is the GNS model.

Table 6 presents the more detailed results of the General Nesting Spatial-type spatial econometric model for the years 2003 and 2017. The table lists the estimated coefficients of independent regressions for each of the four variables associated with the intensity of the armed conflict at the municipal level and presents both direct and indirect effects. The dependent variable is the standardized score of the Icfes test at the municipal level. The table also shows the coefficients of the control variables containing educational and socioeconomic factors of the municipality.

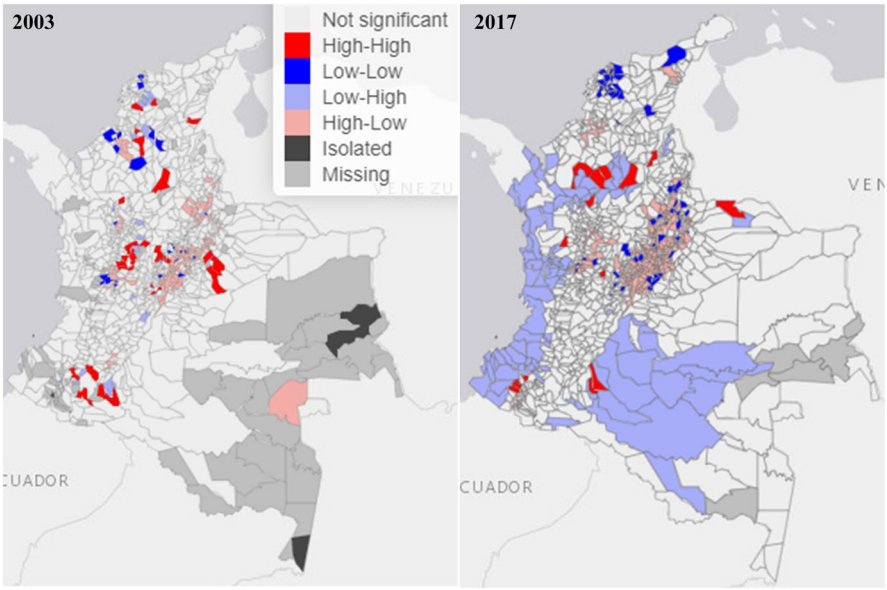

Fig. 1 LISA indicators. Academic performance vs. victims of threats

Table 5 Econometric spatial model specifications. Spatial weighted matrix first order neighbors

	2003						2017					
Victims of homicides	OLS	SAR	SEM	SAC	SDM	GNS	OLS	SAR	SEM	SAC	SDM	GNS
Direct effects	-0.0008	-0.0004	-0.0002	-0.0002	-0.0003	-0.0004	-0.045***	-0.023**	-0.025***	-0.021**	-0.022**	-0.022**
Indirect effects					-0.0006	-0.001					0.010	0.015
ρ		0.893***		0.401***	0.8714***	0.670***		0.783***		0.851***	0.715***	0.807***
λ			0.908***	0.748***		0.437***			0.849***	-0.237**		-0.220*
Forced displacement												
Direct effects	-0.0000	-0.0000	-0.000	-0.000	-0.000	-0.000	-0.001***	-0.0005***	-0.0005***	-0.0005***	-0.0004**	-0.0004***
Indirect effects					-0.000	-0.000					0.0000	0.0002
ρ		0.893***		0.401***	0.871	0.677***		0.777***		0.845***	0.714***	0.813***
λ			0.908***	0.748***		0.426***			0.84***	-0.23**		-0.238**
Terrorism attacks												
Direct effects	-0.013***	-0.011***	-0.008***	-0.009***	-0.010***	-0.011***	-0.19	-0.007	-0.007	-0.007	-0.006	-0.007
Indirect effects					-0.036***	-0.044***					-0.011	-0.005
ρ		0.894***		0.430***	0.872***	0.673***		0.78***		0.859***	0.716***	0.809***
λ			0.906***	0.721***		0.426***			0.851***	-0.255***		-0.225**
Victims of threats												
Direct effects	-0.002*	-0.001*	-0.001	-0.0015	-0.001	-0.001	-0.158***	-0.007***	-0.008***	-0.007***	-0.006***	-0.006***
Indirect effects					-0.001	-0.003					-0.002	-0.001
ρ		0.893***		0.40***	0.871***	0.665***		0.762***		0.830***	0.704***	0.812***
λ			0.907***	0.742***		0.443***			0.834***	-0.220**		-0.256**

Authors' calculation based on data from ICFES, DANE, CEDE, Unidad de Victimas and Banco de la República. *** *P*-value < 0.001; ** *P*-value < 0.05; * *P*-value < 0.10

The results suggest that in 2003, the only conflict intensity variable both directly and indirectly related to academic performance was terrorist attacks. In case of the direct effect, the coefficient of terrorist attacks suggests an effect four times lower than the indirect effect. For every increase of one additional victim of terrorist attacks per 10,000 inhabitants, the municipal average academic performance decreases by at least 0.011 standard deviations. In the case of the indirect effect, the results suggest that when the victims of terrorist attacks increase in neighboring municipalities by one additional victim per 10,000 inhabitants, the academic performance of the municipality under consideration decreases by at least 0.044 standard deviations. This result is the first evidence of confirmation under this spatial model of a negative effect that the armed conflict in the country has had on academic performance, not only due to the intensity of the conflict within the municipality itself but also due to the levels of conflict in the municipalities neighbors.

By 2017, results show a direct negative effect of the variables victims of homicides, displaced persons, and victims of threats. For every increase in one additional victim of homicide per 10,000 inhabitants decreases academic performance in 2017 by 0.022 standard deviations on average. This direct effect is greater than that of displaced persons and victims of threats, which reduce performance by 0.0004, and 0.006 standard deviations. This result generally implies that increasing the intensity of the conflict in the municipality in 2017 negatively affected the academic performance in the same town, while the intensity of the conflict in neighboring municipalities does not seem to have had an impact on academic performance. This is consistent with the retreating of groups outside the law in the more recent conflict scenario which their regional influence changed and consequently so did their regional impacts.

The control variable results show the parameters generally have the expected signs and are more stable with respect to those associated with the conflict variables throughout the years studied. The ratio of students per teacher, the rurality index, and investment in education have a negative relationship with school performance. On the investment in education side, the effect turns out to be counterintuitive and may be associated with the inefficiency of spending due to corruption (some evidence for Colombia can be found in Galvis & Hincapie, 2022), or how the educational system is structured and the items to which the resources turn out to be directed, in which, generally, the items destined towards improvements in coverage and, to a lesser extent, to improve educational quality, prevail.

Conclusions

Colombia has one of the oldest armed conflicts in the world, and it experiences relevant effects in several dimensions. In education, the impacts relate to damage to physical infrastructure, restriction of educational resources, alteration of school calendars, and increased risk and uncertainty on behalf of families, students, and teachers. In this context, this study evaluated the incidence of armed conflicts on the academic performance of high school students at the municipal level over two periods

Table 6 Results of the General Nesting Spatial-type spatial model. Spatial weighted matrix first order neighbors

Dependent variable: standardized score	2003				2017			
	Victims of homicides	Forced displacement	Terrorism attacks	Victims of threats	Victims of homicides	Forced displacement	Terrorism attacks	Victims of threats
Direct effects								
Victims	-0.0004	-0.000	-0.011***	-0.001	-0.022**	-0.0004***	-0.007	-0.006***
Students per teacher	0.002	0.002	0.002	0.002	-0.010***	-0.010***	-0.011***	-0.011***
Investment in education	0.011**	0.010**	0.011**	0.010	-0.055***	-0.049***	-0.057***	-0.046***
Tax incomes	0.215	0.220	0.252	0.194	0.422***	0.415***	0.409***	0.417***
Capital city	0.0008	0.014	-0.015	0.003	0.515***	0.526***	0.523***	0.507***
Rurality index	0.008	0.010	0.054	0.021	-0.693***	-0.684***	-0.669***	-0.681***
Presence of conflict	0.027	0.015	0.053	0.023	-0.010	-0.034	-0.031	0.008
Indirect effects								
Victims	-0.001	-0.000	-0.044***	-0.003	0.015	0.0002	-0.005	-0.000
Students per teacher	0.010*	0.010*	0.009	0.010	0.000	0.0003	0.000	-0.003
Investment in education	0.006	0.0045	0.008	0.004	-0.092***	-0.085***	-0.090***	-0.067***
Tax incomes	-0.034	-0.018	-0.127	-0.114	-0.398**	-0.383**	-0.385**	-0.405**
Capital city	0.363	0.423	0.266	0.380	-0.155	-0.197	-0.154	-0.269
Rurality index	0.317	0.329	0.314	0.346	0.942***	0.920***	0.940***	0.903***

Table 6 (continued)

Dependent variable: standardized score	2003				2017			
	Victims of homicides	Forced displacement	Terrorism attacks	Victims of threats	Victims of homicides	Forced displacement	Terrorism attacks	Victims of threats
Presence of conflict	0.130	0.061	0.161	0.083	0.041	0.059	0.067	0.194
Constant	-0.433***	-0.440***	-0.447***	-0.427***	0.404***	0.382***	0.400***	0.409***
ρ	0.670***	0.677***	0.673***	0.665***	0.807***	0.813***	0.809***	0.812***
λ	0.437***	0.426***	0.426***	0.443***	-0.220*	-0.238**	-0.225**	-0.256**
Observations	927	927	927	927	1,074	1,074	1,074	1,074

Authors' calculation based on data from ICFES. DANE. CEDE. Unidad de Victimas and Banco de la República. *** *P*-value < 0.001; ** *P*-value < 0.05; * *P*-value < 0.10

of time characterized by high and low intensity of armed conflict. The work used a General Nesting Spatial-type spatial model to evaluate the direct and indirect effects of the armed conflict.

Results suggest that in 2003, only the variable of victims of terrorist attacks presented direct and indirect negative effects on academic performance. By 2017 and once a peace agreement between the government of the Juan Manuel Santos and the main subversive group FARC-EP in the country was signed, the direct effect of the attacks disappeared, and the victims of homicides, displaced persons, and threats reported negative direct effects on academic performance. These results indicate the changes in the nature, composition, and intensity of the conflict in recent years. In particular, the effects of terrorist attacks on academic performance vanished by 2017 as a result of the weakening of the FARC that historically used this method to demonstrate power. In the same way, the statistical significance of the effect of the variables of homicides, displaced persons, and threats reflects a new atomized scenario of smaller heterogeneous subversive groups that use these practices to intimidate populations.

The econometric results are aligned with the ideas of Prieto, et al. (2014) which affirm that the Colombian state had to face "a series of transformations in the structures, actions, and modus operandi of the guerrilla groups, which respond to the new military plans of the public force and represent a challenge to achieve weakening them" (p.52). Furthermore, according to the GMH (2013), frequent and low-intensity violence has occurred in this new version of the conflict. "Selective assassinations, forced disappearances, kidnappings, small massacres prevail in the armed conflict" (p.42). According to the report. these crimes have been strategies of the armed groups to hide or silence their victims.

The vanishing indirect effects of the terrorist attacks on academic performance over the period considered highlights the positive impact of the de-escalation of armed conflict and the geographical retreating of groups in the country. According to Ríos (2020), there is a relationship between border or peripheral scenarios and the presence of coca-growing economies that favor the finances of groups who consider themselves above the law. In this way, it is key that the government continue efforts to bargain new agreements with other armed and illegal groups. The results also highlight the institutional factors that should be strengthened to improve educational quality at a municipal level. Such factors include a higher teacher-student ratio and more efficient educational spending according to the econometric results.

In Colombia, regional disparities arise in academic performance throughout the different stages of conflict. Results in this paper show that indirect effects appear in periods of high conflict intensity widening the academic gap between regions. Accordingly, the state should reinforce social intervention and inclusive policies in the territories most affected by the conflict. Reducing these regional gaps in educational matters should be a priority for national, regional, and local governments. So, the regions most affected by the conflict should receive differential treatment to offset the negative effects of the conflict. This differential approach can be reflected by better conditions for successful learning and investments to increase the quality of education.

Appendix 1

Table 7 Econometric spatial model specifications. First- and second-order neighbors

	2003						2017					
Victims of homicides	OLS	SAR	SEM	SAC	SDM	GNS	OLS	SAR	SEM	SAC	SDM	GNS
Direct effects	-0.0008	-0.0003	-0.0003	-0.0002	-0.0003	-0.0000	-0.045***	-0.022**	-0.020**	-0.019**	-0.019*	-0.023**
Indirect effects					-0.0000	0.001					-0.009	0.008
ρ		0.924***		1.10***	0.919***	-0.69***		0.791***		-0.646***	0.640***	0.909***
λ			0.925***	-0.722***		1.107***			0.862***	0.980***		-0.797***
Forced displacement												
Direct effects	-0.0000	-0.000	-0.000	-0.0000	-0.0000	-0.000	-0.001***	-0.0006***	-0.0006***	-0.0005	-0.0005***	-0.0006***
Indirect effects					0.0000	-0.000					0.0004	0.0004
ρ		0.924***		1.109***	0.918***	-0.692***		0.784***		-0.640***	0.644***	0.911***
λ			0.925***	-0.72***		1.107***			0.642***	0.980***		-0.800***
Terrorism attacks												
Direct effects	-0.132***	-0.0006***	-0.003	-0.005***	-0.006***	-0.003*	-0.019	-0.021**	-0.023**	-0.019**	-0.018*	-0.017*
Indirect effects					-0.015***	-0.003					0.06*	0.036
ρ		0.920***		1.108***	0.897***	1.159***		0.798***		-0.636***	0.639***	0.901***
λ			0.925***	-0.739***		-0.814***			0.867***	0.980***		-0.762***
Victims of threats												
Direct effects	-0.002*	-0.001*	-0.001*	-0.0009	-0.001	-0.0006	-0.015***	-0.009***	-0.012***	-0.010***	-0.011***	-0.010***
Indirect effects					0.002	0.004					0.007**	0.007**
ρ		0.924***		1.109***	0.921***	-0.675***		0.765***		-0.729***	0.646***	0.907***
λ			0.926***	-0.717***		1.107***			0.852***	1.033***		-0.803***

Note: Authors' calculation based on data from ICFES. DANE. CEDE. Unidad de Victimas and Banco de la República. *** P-value < 0.001; ** P-value < 0.05; * P-value < 0.10

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Declarations

Conflict of interest None.

References

Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis., 27*, 93–115.

Akresh, R., y de Walque, D. (2008). A*rmed Conflict and Schooling: Evidence from the 1994 Rwandan Genocide.* Working paper No. 4606. The World Bank, Development Research Group, Human Development and Public Service Team. http://hdl.handle.net/10986/6646.

Brück, T., Di Maio, M., & y Miaari, S. (2019). Learning the hard way: The effect of violent conflict on student academic achievement. *JOurnal of the European Economic Association, 17*(5), 1502–1537. https://doi.org/10.1093/jeea/jvy051

Chacón. M. (2004). Dinámica y determinantes de la violencia durante "la violencia" en Colombia. DOCUMENTO CEDE 2004–16. https://economia.uniandes.edu.co/components/com_booklibrary/ebooks/D2004-16.pdf.

Chamarbagwala, R. y Morán, H. (2010). The human capital consequences of civil war: Evidence from Guatemala. *Journal of Development Economics, 94* (1), 41-61.https://doi.org/10.1016/j.jdeveco.2010.01.005.

Davies, L. (2004). *Education and conflict. Complexity and chaos*. Routledge.

Díaz. E. (2019). Impacto de la Exposición al Conflicto Armado en el Desempeño Académico: Evidencia para el caso de desmovilización paramilitar del 2003–2006 en Colombia. https://repository.urosario.edu.co/bitstream/handle/10336/19036/EdgarAndres-DiazVillarruel-2019.pdf?sequence=4.

Durbin, J. (1960). Estimation of Parameters in Time-Series Regression Models. *Journal of the Royal Statistical Society., 22*(1), 139–153.

Elhorst, J. (2010). Applied Spatial Econometrics: Raising the Bar. *Spatial Economic Analysis., 5*(1), 9–28. https://doi.org/10.1080/17421770903541772

Galvis. L. (2015). La eficiencia del gasto público en educación en Colombia. Economía & Región. *9*(2). 75–98. https://revistas.utb.edu.co/index.php/economiayregion/article/view/106/87

Galvis Ciro, J. C., & Hincapié-Vélez, G. D. (2022). The Effects of Corruption on Government Spending in the States of Colombia. *Apuntes del Cenes*, *41*(73). https://doi.org/10.19053/01203053.v41.n73.2022.13555.

Gamboa. A.. Urbina. J. and Prada. R. (2019). Conflicto armado y vulnerabilidad: determinantes del abandono escolar en la región del Catatumbo. *Saber-Ciencia y libertad. 14*(2). 222–231. https://doi.org/10.18041/2382-3240/saber.2019v14n2.5891.

Gómez, S. (2016). Educational achievement at schools: Assessing the effect of the civil conflict using a pseudo-panel of schools. *International Journal of Educational Development., 49*, 91–106. https://doi.org/10.1016/j.ijedudev.2016.02.004

Gómez, S. (2017). Civil Conflict and Educational Achievement: The Case of the Colombian Secondary School Exit Examination. *Colombia Internacional., 92*, 73–103. https://doi.org/10.7440/colombiaint92.2017.03

Grupo Nacional de Memoria Histórica [GMH] (2013). ¡BASTA YA! Colombia: Memorias de Guerra y Dignidad. Informe general Grupo de Memoria Histórica. https://www.centrodememoriahistorica.gov.co/descargas/informes2013/bastaYa/basta-ya-colombia-memorias-de-guerra-y-dignidad-2016.pdf.

Hanushek, E. A. (1979). Conceptual and empirical issues in the estimation of educational production functions. *Journal of Human Resources*. Vol. 14. No. 3. pp. 351-388

Haugan. G. (2016). The effect of urban violence on student achievement in Medellin. Colombia. *Documentos CEDE 014326.* Universidad de los Andes. Centro de Estudios sobre Desarrollo Económico (CEDE).

Instituto Colombiano para la Evaluación de la Educación (Icfes). (s.f). Base de datos de las Pruebas Saber 11.

Justino. P. (2011). Violent Conflict and Human Capital Accumulation. CRPD Working Paper. 8. Centre for Research on Peace and Development.

Miranda, J., Quintero, M., & Higuera, V. (2015). Efectos del Conflicto Armado y el Conflicto Socioeconómico en el aprendizaje civilidad: La función de producción educativa en el caso del conflicto interno en Colombia. *Investigaciones De Economía De La Educación., 10*(27), 521–550.

Monteiro, J. y Rocha, R. (2013). *Drug battles and school achievement: evidence from Rio de Janeiro's favelas.* Working paper, 2013/05, Caracas. CAF. http://scioteca.caf.com/handle/123456789/250.

Moran, P. A. (1948). The interpretation of statistical maps. *Journal of the Royal Statistical Society: Series B (methodological)., 10*, 243–251.

Munevar. S.. Silva. A. & Sarmiento. J. (2019). Exposición al conflicto armado y logro académico en Colombia. *Revista Desarrollo y Sociedad. 83*. 13–54. https://doi.org/10.13043/dys.83.1.

Naciones Unidas (2010). Informe del Representante Especial del Secretario General para los Niños y los Conflictos Armados. Nueva York. Asamblea General de las Naciones Unidas (A/65/219).

Organización de las Naciones Unidas para la Educación. la Ciencia y la Cultura [UNESCO]. (2011). Una crisis encubierta: conflictos armados y educación. Informe de seguimiento de la Educación para todos en el mundo. Primera Edición. Francia.

Organización de las Naciones Unidas para la Educación. la Ciencia y la Cultura [UNESCO]. (2015). Docum2015ento de Política 21. Informe de Seguimiento de la Educación para todos en el mundo..

Orraca. P. (2018). Crime Exposure and Educational Outcomes in Mexico. Ensayos Revista de Economía. *37*(2). 177–212. DOI. https://doi.org/10.29105/ensayos37.2-3.

Osorio, J. (2016). La escuela en escenarios de conflicto: Daños y desafíos. *Hallazgos., 13*(26), 179–191.

Parlow, A., (2011). Education and armed conflict: the Kashmir insurgency in the nineties. MPRA Paper No. 38010. Munich Personal Repec Archive. https://mpra.ub.uni-muenchen.de/38010/.

Prieto. C. Rocha. C. and Marín. I. (2014). Seis tesis sobre la evolución reciente del conflicto armado en Colombia. Informes FIP. *23* http://cdn.ideaspaz.org/media/website/document/5436b8cdbf6e1.pdf

Quintero. M. Alvarado. S. and Miranda. J. (2016). Conflicto armado. variables socio-económicas y formación ciudadana: un análisis de impacto. *Revista Latinoamericana de Ciencias Sociales. Niñez y Juventud. 14* (1). 147–161. http://www.scielo.org.co/pdf/rlcs/v14n1/v14n1a10.pdf.

Ramos. I. and Miranda. M. (2012). *Impacto de la violencia y el conflicto armado y su incidencia en el aprendizaje y el desarrollo psicosocial de los niños. niñas y adolescentes de la Institución educativa Departamental de Guáimaro (Magdalena).* [Tesis de Especialización. Universidad de la Costa]. REDICUC. http://hdl.handle.net/11323/4691.

Restrepo. J.. Spagat. M. and Vargas. J. (2004). The Dynamics of the Colombian Civil Conflict: A New Data Set. Homo Oeconomicus. 21(2): 396–428 https://www.cerac.org.co/es/assets/files/articulos/ThedynamicsoftheColombian.pdf.

Rodríguez. C. & Sánchez. F. (2010). Books and guns: The quality of schools in conflict zones. *Documento CEDE No. 38*. Bogotá: Centro de Estudios sobre Desarrollo Económico (CEDE).

Ríos, J. (2020). La(s) geografía(s) de la violencia guerrillera en Colombia 2012–2020. Real Instituto Elcano, Documento de trabajo 11/2020. http://www.realinstitutoelcano.org/wps/portal/rielcano_es/contenido?WCM_GLOBAL_CONTEXT=/elcano/elcano_es/zonas_es/dt11-2020-rios-geografias-de-la-violencia-guerrillera-en-colombia-2012-2020.

Sánchez. F.. Díaz. A. & Formisano. M. (2003). Conflicto. violencia y actividad criminal en Colombia: un análisis espacial. DOCUMENTO CEDE 2003–05. https://economia.uniandes.edu.co/components/com_booklibrary/ebooks/D2003-05.pdf

Shany, A. (2018). *Too Scared for School? The Effects of Terrorism on Student Achievement.* [Job Market Paper, University of Jerusalem]. Department of Economics.

Sharkey, P. (2010). The Acute Effect of Local Homicides on Children's Cognitive Performance. *Proceedings of the National Academy of Sciences., 107*(26), 11733–11738. https://doi.org/10.1073/pnas.1000690107

Sharma. H. and Gibson. J. (2019). Civil War and International Migration from Nepal: Evidence from a Spatial Durbin Model. University of Waikato. Working Paper in Economics 19/06. ftp://sys-dmzhost.its.waikato.ac.nz/wai/econwp/1906.pdf.

Sommers. M. (2002). Children. education and war: reaching Education for All (EFA) objectives in countries affected by conflict (English). Social development papers. Conflict prevention and reconstruction series CPR no. 1. Washington. D.C.

Velásquez. J. & García. L. (2018). Conflicto armado y educación: una mirada prospectiva de la enseñanza de Historia en Colombia. https://ciencia.lasalle.edu.co/lic_lenguas/485.