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Authors

Ortiz-Correa, Javier Santiago
Dinar, Ariel

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ORIGINAL ARTICLE

Civil war's impact on the environment and on access to water and sanitation services: the case of Colombia

Javier Santiago Ortiz-Correa[1] · **Ariel Dinar**[2]

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Abstract
Civil wars may result in deteriorated environmental conditions, and, in turn, may reduce the quantity and quality of water available to households. This paper explores the impacts of the Colombian civil war on access to water and sanitation services, using a theoretical household model in which civil war enters as a tax on the household income and on the prices of goods. The paper takes a unique approach by exploring how different levels of conflict intensity impact the probability of curtailing access to water and sanitation services. Empirical results suggest that civil war reduces access to water and sanitation services and deteriorates children's health. However, households adapt by internalizing the conflict intensity experienced.

Keywords Civil war · Water · Sanitation services · Household · Health · Colombia · DHS

JEL Classification I15 · N46 · Q25

Introduction

Nearly 90 countries in the developing world experienced civil wars between 1950 and 2009 (Prio Armed conflict version 4-2009) and 20% of the nations have experienced at least 10 years of civil war since 1960 (Miguel and Blattman 2010).[1]

Civil wars have many negative effects on states and their populations. They change the trajectories of growth, inflation, and investment (Chen et al. 2008) and the GDP of the affected countries (Murdoch and Sandler 2002; Bove et al. 2017). Governments may be forced to cut social expenditure to face the military challenges (Lai and Thyne 2007). Civil war leads to worse-off labor market outcomes and to reduced firm size (Galdo 2013; Collier and Duponchel 2013). Civil war interacts with economic factors to cause forced migration (Adhikari 2012). Levels of civic participation, social cohesion, and trust-based transactions can experience changes in a country experiencing a civil war (De Luca and Verpoorten 2015; Gilligan et al. 2014). Civil war reduces school attainment (Akresh and de Walque 2008; Chamarbagwala and Moran 2011; Leon 2012) and the height of children born during the fighting period (Akresh et al. 2011). It increases child and infant mortality (Urdinola 2004), and the probability of miscarriage (Camacho 2008). Civil war also impacts the ratios of male-to-female births (Catalano et al. 2005), and the length of pregnancies and birth weights (Smits et al. 2006). Civil war harms women's health (Domingues and Barre 2013) and causes the reemergence of infections and changes in biosecurity (Doganay and Hayati 2016).

One aspect that has not been explored is how civil war may reduce access to water because of the destruction of infrastructure, deforestation, pollution of water bodies, or higher use of water resources. Civil war limits access to water, destroys sewerage systems, prevents families from using proper sanitation facilities, and forces its victims to increase their contact with excreta and polluted water sources.[2] Recent evidence indicates the extent of the

✉ Javier Santiago Ortiz-Correa
javiersantiago.ortiz@gmail.com

[1] Department of Economics, University of California Riverside, Riverside, USA

[2] School of Public Policy, University of California, Riverside, Riverside, USA

[1] No more recent versions of the Prio-Uppsala Conflict Datasets are available.

[2] Two different concepts of war are used throughout this paper: war and civil war (also called internal armed conflict, civil conflict, or armed strife). In a civil war, rebel groups fight the army of the state; civil wars are featured by violation of human rights through use of guerrilla war tactics by the rebels and groups with different ideologies. In a civil war, the rebels seek to overthrow the government.

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disruption in access to water and sanitation services in conflict areas. In Syria, 7.6 million people are in acute need of access to water and sanitation as conflict implied lack of water treatment, water pollution due to infrastructure damages, and leaks and inadequate chlorination (UNICEF, 2022). In Ukraine, the recent military operations have resulted in a need to replace approximately 60% of the water pipelines in the most violent regions (EuroNews, 2022).

Two main approaches exist in the literature of civil war. The institutional approach (Collier 1999; Collier and Hoeffler 2002) interprets civil war as the outcome of institutional failures to resolve the grievances or the greed-driven conflicts among societal segments (Collier and Hoeffler 2004). The environmental approach (Gledistch 1998) argues that higher population growth rates lead to deteriorated environmental conditions, which in turn result in increased resource scarcity and competition that altogether translate into higher risk of violence.

The likelihood of war increases with medium-to-high levels of land degradation and very high levels of water scarcity (Raleigh and Urdal 2007). Environmental shocks that lead to severe income variability increase the probability of civil war (Miguel et al. 2004). Institutions act either to prevent war, when tackling its structural causes (Baird 2011), or are changed as a consequence of war (Kurf and Funfgeld 2006).

The effects of war on the environment depend on the type of war, the kind of weapons and strategies being used, its duration and its intensity (Biswas 2000). Improved war technology (Westing 1980) and preparedness for war (Singer and Keating 1999) increase the environmental consequences of armed conflict. However, war (and preparedness for it) could have a positive impact on the environment by reducing access to nature reserves (Tucker and Russell 2004). Negative effects will occur after either massive and extended military disruptions and destruction or by frequent small disruptions (McNeely 2000). For instance, desert surfaces were disturbed after the first Gulf War (El-Shobokshy and Al-Saedi 1993) and deforestation intensified in countries experiencing an armed conflict (Reuveny et al. 2010). Additionally, land cover and land use changed in Sierra Leone as a consequence of civil war (Wilson and Wilson 2013).

By coping with armed conflicts, households engage in strategies according to the risk of being victimized and to the risk of facing poverty due to the conflict[3] (Justino 2009). Refugee's impact on the environment could be explained by their short-sighted decisions and ignorance of the local environmental and resource management institutions (Jacobsen 1997).

When a conflict destroys water sources and water-supporting infrastructure, or implies their pollution, it may increase the opportunity costs of collecting water (Nauges and Van Den Berg 2009). Access to improperly treated or polluted water is linked to infectious diseases and high infant mortality rates (Montgomery and Elimelech 2007). Nevertheless, the actual effect of water quality on children's health, ultimately, depends on how children's health enters into the parental utility function (Jalana and Ravallion 2003).

This paper explores the impacts of civil war on access to water and sanitation services, using household-level data from Colombia. The paper contributes to the literature on the environmental impact of civil war in four ways. First, it takes the household as the unit of analysis. Previous civil water impact studies (Raleigh and Urdal 2007; Reuveny et al. 2010) only explored the national or regional ecological burden of civil war. The second contribution is a theoretical household utility maximization model, where civil war is introduced as a tax on prices of goods and income, which could have contradictory effects. Third, it develops a stock of violence index from variables that measure violence intensity, taking the Colombian internal armed conflict as a case study. The fourth contribution is the use of the household-level Demographic and Health Survey (DHS) dataset to explore how access to water changes throughout a civil war. The DHS is preferred, since its main source of data is women in reproductive age. It is for these women that the health of the children is the most relevant.[4] While the Colombian internal armed conflict is the empirical application, mainly due to the availability of relevant data, the approach developed is appropriate to explore the impact of civil war on access to water and sanitation services anywhere around the world.

Materials and methods

Study area[5]

Colombia is a South American country (Fig. 1) that has experienced a civil war (or internal armed conflict) since the late 1960s. High concentration of land property and

[3] Justino (2009) envisions circumstances in which households may actively participate in a civil war. This paper assumes that households are victimized, since civil wars are devastating for life, health, living standards, and for human and physical capital (Miguel and Blattman 2010).

[4] For full expanded literature review, threats of identification and tables of results, visit Ortiz-Correa and Dinar (2018) available at http://spp.ucr.edu/publications/civil_war_impact.pdf.

[5] This paper is about the effect of the Colombian conflict on the access to water and sanitation services and not about the dynamics and historical evolution of the conflict itself. Other papers exploring issues related to civil wars and their effects (Akresh and de Walque 2008; Akrest et al. 2011) provide only an overview of the conflict. An in-depth analysis of the conflict is beyond the scope of this paper.

Fig. 1 Colombia. Source: https://commons.wikimedia.org/wiki/File:Colombia_in_South_America.svg

institutional failures led to the civil war (Nahzri 1997). Three main groups have been fighting: the state army, the left-wing terrorists (LWT), and the right-wing terrorists (RWT) groups. Conflict intensified after the 1980s (Fig. 2), as the RWT and LWT groups became involved in drug production and trafficking (Ortiz 2002). Illicit drugs' trade in Colombia lengthened the conflict by providing financial resources to the weaker parties to keep on fighting (Ross 2004a, b). After the collapse of the peace talks conducted during 1999–2002, the *Plan Colombia* (Veillette 2005) helped the state's army to get on the offensive from 2002 until 2010.

The internal conflict started fading out after the election of Juan Manuel Santos as President in 2010. His government started negotiations with the main guerrilla group, FARC, in Cuba. When Mr. Santos was reelected in 2014, he continued the negotiations until the parties reached an agreement on a peace treaty in 2016. Parallel to the negotiations with FARC, the government has carried out negotiations with the second largest left-wing rebel group, ELN, but no agreement has been reached.

The Colombian national constitution (Articles 361 and 366) relates water and sanitation to the rights of life and health (Constitutional Court, T-232, 1993). The national government coordinates with local municipalities the investments aimed at increasing access to water and sanitation. Colombia has increased the percentage of population with access to improved sanitation facilities (from 68% in 1990, to 74% in 2008 and to 89.6% in 2017) and with access to improved water sources (from 88% in 1990, to 92% in 2008 and to 95.7% in 2017) (World Bank 2012; WHO/UNICEF 2019). Water scarcity is not an issue in Colombia, since the total withdrawal of freshwater only accounts for 0.59% of the total internal resources (Ministerio del Medio Ambiente y Desarrollo Sostenible 2010). The incidence of diarrhea caused 4% of the child mortality in the country (WHO 2012a; b).

The theoretical model and hypotheses

The theoretical foundation for this study is the household utility maximization model. We define households' utility $U(.)$[6] as a function of a composite good X, a quality-adjusted amount of water qw, the health of children in the household H_C, and leisure time l. The quality-adjusted amount of water is used for household consumption. Children's health is assumed to be a direct function of water consumption, because the better the water quality and its availability, the more likely households are to engage in health- improving practices. Households act as price takers when it comes to the price of a composite good, p_X and of water p_w. The household utility function to be maximized is

$$U\left(X, qw, H_C(qw), l\right). \tag{1}$$

Access to water is defined as the availability of at least 20 L per person per day from a source within one kilometer around the dwelling (WHO 2011a). Water quality is defined in terms of microbial water quality (pollution levels from fecal microorganisms) and chemical water quality (pollution originating from the materials used in the potabilization and distribution of water) (WHO 2011b). The World Health Organization (WHO) categorizes the sanitation facilities into: improved sanitation (connection to public sewers, connection to septic systems, pour-flush latrines, simple pit latrines, and ventilated improved pit latrines) and unimproved sanitation (service or bucket latrines where excreta is manually removed, public latrines, and open latrines). In the model, water quality q, observed by the household, captures

[6] The utility maximization framework has been used in previous research, such as: child mortality and fertility (Wolfe and Behrman 1982; Ben-Porath 1976; Rosenzweig and Evenson 1977), labor supply and intrahousehold bargaining and behavior (Rosenzweig 1980; Boulier and Rosenzweig 1984; Ravallion and Dearden 1988; Behrman and Deolalikar 1993), and policy evaluation (Rosenzweig and Wolpin 1986).

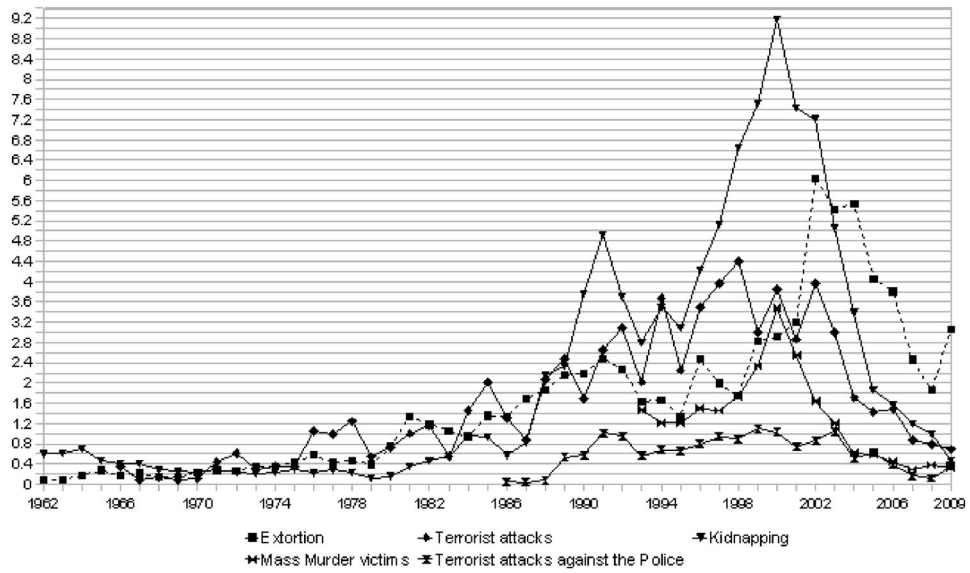

Fig. 2 Main conflict indicators 1962–2010 (per 100,000 inhabitants). Source: Policia Nacional de Colombia, Revista Criminalidad, 2008–2010

both the quality of the drinking water and the level of sanitation on-site. It is assumed that $0 < q < 1$, such that $q > \underline{q}$ ($\underline{q}$ being the WHO standards) represents the appropriate sanitation technologies and levels of water quality. Any effect of civil war on sanitation will be captured by the value of the quality parameter. Households will minimize their water consumption, $w \to 0$, if $q < \underline{q}$, and the marginal utility of children's health will be negative.

Household income originates from a monetary endowment Y, and wages r. Households observe wages in the market. Time is allocated between work, L, and leisure, l (such that $L + l = 1$). The total budget constraint faced by the household can be expressed as

$$Y + (1 - l)r = p_X X + p_w w. \tag{2}$$

Civil war is introduced into this model as a tax on income and on the prices of goods. Prices increase during civil war because of loose government monetary policy in need to fund the military campaigns (Chen et al. 2008). Those price changes reduce the welfare of households (Justino 2008). The tax on income might be the result of the actual destruction of assets and infrastructure, or it might be levied indirectly through the reduction in government expenditures on services (Lai and Thyne 2007). Governments may also impose extra taxes on firms and wealthy citizens. Extortions and kidnappings, faced by households, act as a tax, reducing the available income of households.

The intensity of the conflict defines the civil war taxes and the environmental footprint. War acts as an echo and the effects of violence weakens as time passes by Gleditsch (1998). Environmental effects can be created as a result of massive disruptions or from small disruptions that are self-regenerated (Mcneely 2000). Therefore, the environmental impact of civil war at time t depends on war events at time t, plus the echo or regeneration of violent and war events that occurred in time $t-1, t-2, \ldots, t-\tau$, where τ is the horizon of the analysis.

Our goal in this paper is to estimate the impact of the conflict. This paper does not explain the process of generating the conflict data and does not predict future levels of conflict (as in Odhuno 2012). Because the conflict data will be used in the framework of a household utility maximization model, we adapt and apply the concept of "habit formation" (Carroll et al. 2000) to the case of civil war. In this paper, the habit stock is a stock of conflict-related events that have an impact on household's decisions by changing prices and income, acting as a tax. The stock is computed as a simple aggregation or as weighted average for different time horizons (1, 5, 10, and 20 years). When using the weighted average, it is proposed, following Carroll et al. (2000) that weights grow either at 5%, 10% or at 20% per year. Lower growth rates occur in values closer to a simple aggregation. Higher weights occur when the impact of conflict is mainly in the year prior to the household interview.

At any year t, the environment deteriorates due to a stock of violence SV_t. Weights are given in such a way that the closer the civil war event is to year t, the higher the impact will be.

The stock of violence is $SV_t = \sum_{t-\tau}^{t} \beta_t V_t$, where β_t stands for the weight assigned to year t and V_t is the civil war intensity in year $t, t-1, t-2, ..., t-\tau$. τ is the length in years for

which the individual calculates the stock of violence and that can be $\tau = \tau_1, ..., \tau_n$ years. To account for a higher weight in years closer to t, the weights are proposed to grow at a fixed rate, such that$\beta_0 + (1+\eta)^{t-\tau}\beta_0 + ... + (1+\eta)^{t-\tau}\beta_0 = 1$, and $\eta = \eta_0, \eta_1, ..., \eta_n$.

The income tax of civil war can be defined as a function $g(.)$ increasing in the stock of violence (SV_t) and decreasing in the quality of institutions (QI_t). Better government and social institutions can help households cope easier with civil war. The income tax is bounded between 0 and 1, such that

$$T_\theta = g\left(SV_t, QI_t\right)\epsilon\{0...1\}. \tag{3}$$

The price tax of civil war is a function $h(.)$ decreasing in the quality of institutions and increasing in the stock of violence, and, like the income tax, will be bounded between 0 and 1, such that

$$\pi_\alpha = h\left(SV_t, QI_t\right)\epsilon\{0...1\}. \tag{4}$$

The utility maximization problem for the household during civil war is

$$Max_{X,w,l}U(X, qw, H_C(qw), l) \tag{5}$$

$$s.t(1-T_\theta)Y + (1-T_\theta)(1-l)r - (1+\pi_\alpha)p_X X - (1+\pi_\alpha)p_w w = 0.$$

After setting up the Lagrangian and deriving the First-Order and Second-Order Conditions, the comparative statics are calculated (see Ortiz-Correa and Dinar 2018).

The Second-Order Conditions involve three terms. First, $\frac{r(1-T_\theta)}{p_X(1+\pi_\alpha)}$ is the net real income from the labor of the household.

As for the second term, $\frac{U_{lw}+U_{lH_C}H_C^{'}}{U_{Xw}+U_{XH_C}H_C^{'}}$, the numerator is the gains in leisure from children's health and from quality-adjusted water availability. The denominator includes the changes in the marginal utility of the composite good from changes in quality-adjusted water availability and from children's health. Note that the effects of children's health on leisure, and the consumption of the composite good, are amplified by $H_C^{'}$, and supposed to be directly dependent on the quality-adjusted water availability.

Finally, the third term, $\frac{U_{wl}+U_{H_Cl}}{U_{wX}+U_{H_CX}}$, is the ratio of the changes in the marginal utility of water and children's health, resulting from changes in the amount of leisure and the level of consumption of the composite good.

To fulfill the second-order condition, one of two results has to hold

Either $\frac{U_{lw}+U_{lH_C}H_C^{'}}{U_{Xw}+U_{XH_C}H_C^{'}} < \frac{r(1-T_\theta)}{p_X(1+\pi_\alpha)}$ or $\frac{r(1-T_\theta)}{p_X(1+\pi_\alpha)} < \frac{U_{wl}+U_{H_Cl}}{U_{wX}+U_{H_CX}}$.

The first result, $\frac{U_{lw}+U_{lH_C}H_C^{'}}{U_{Xw}+U_{XH_C}H_C^{'}} < \frac{r(1-T_\theta)}{p_X(1+\pi_\alpha)}$, suggests that the ratio of the gains in leisure to the gains in the composite good consumption derived from children's health and water consumption is smaller than the net real income. Households require sufficient income to afford the water needed for healthy children to enjoy their leisure time and the consumption of the composite good.

The second result of the comparative statics is $\frac{r(1-T_\theta)}{p_X(1+\pi_\alpha)} < \frac{U_{wl}+U_{H_Cl}}{U_{wX}+U_{H_CX}}$. This is the mathematical representation of the fact that it is impossible for all household members (not the children) to fully capture the benefits from healthier children and water availability. It is through decisions on leisure time and consumption of the composite good that households cope with the negative externalities of war.

Based on the theoretical results, the following hypotheses are set to be empirically tested using the available data from Colombia:

Hypothesis 1: The impact of civil war on households is realized through taxes on prices and on income. As those taxes increase, the quantity and the quality of water consumed by households is reduced.
Hypothesis 2: An increase in any of the civil war taxes reduces the access to improved sanitation facilities and further reduces the quality of water.[7]
Hypothesis 3: The quality of institutions counteracts with increases in the conflict intensity (i.e., its effect, in absolute value, is larger than the effect of the stock of violence).

Data sources

Three sources of data were used for the empirical analysis: (1) the Colombian National Police reports on the state-level yearly values of the selected conflict indicators, (2) the six waves of the DHS[8] for Colombia for household information on access to water, and (3) proxy variables of institutional quality from the Colombian Statistical Bureau (DANE).

[7] Water quality level is not directly addressed, since such measure at the state level is not available. Any negative impact of civil war on access to sanitation services, like lack of toilet connection to the sewerage, will reduce the quality of water, by increasing the probability of contact between the excreta and water sources (as defined by WHO).

[8] The DHS is extensively used as a dataset in research on developing countries, even though, in most cases, it is not a panel dataset. The sampling strategy guarantees national representativeness. The concepts of access to water and sanitation services are taken as defined by the DHS for the Colombian waves. There might be a concern about the representativeness of the survey if households could not be surveyed in the most violent places. The results have to be taken as a lower bound of the real effect of civil conflict on the access to water and sanitation.

Internal armed conflict data

The conflict data are reported by the Colombian National Police.[9] The variables selected for our analysis are: number of extortions (from 1962 to 2010), kidnappings (from 1962 to 2010), terrorist attacks (from 1966 to 2010), mass-murder victims (from 1993 to 2010), and attacks against the police (from 1986 to 2010) (all of them per state and per 100,000 inhabitants). For each conflict indicator, the stock of violence was computed per state and according to the DHS survey year, either as an aggregated or as a weighted average value for the entire period with a 10% growing weight ($\eta = 0.1$) or a 20% growing weight ($\eta = 0.2$), over different periods of time ($\tau = 1, 5, 10, 20$ years). Environmentally speaking, putting higher weight on recent violent events accelerates the decay of the environmental impact of violence from previous years. Such a decay can be explained by the recuperation of natural systems or by households learning to better cope with conflict.

Demographic and health surveys

We use all six waves of surveys of the DHS that correspond to different stages during the Colombian internal armed conflict: low-intensity conflict period (1986 wave); peak years of the drug-cartels terrorist offensive (1990 wave); LWT fully involved in drug-trafficking and RWT rapidly expanding (1995 wave); the highest levels of LWT- and RWT-committed crimes (2000 wave); and the years of the government offensive on all terrorist groups (2005 and 2010 waves). We did not use the 2015 wave of the DHS in our analysis for several reasons. First, the country started a peace negotiation process after 2011 that culminated in the signature of the peace agreement in 2017. Second, the dynamics of the conflict changed drastically after the government reduced military operations against the left-wing groups. And, third, the country started experiencing a type of violence more related to organized crime funded with the revenues from drug-trafficking, no longer vying for institutional change or territorial control. Since the main goal of the paper is to explore how households behave under different civil war intensity levels, the new type of violence necessitates a different research approach.

The following variables were used or created based on the DHS data: Water on premise is a dummy for all households whose main source of water is piped water, a well in the residence, the yard or the plot, rainwater, or bottled water. When the water source is not on premise, the DHS asks for the time spent going to and from the water source. The time to water source is used as a proxy for the opportunity cost of water, because that is the time that the household cannot allocate to the labor market or leisure activities. The last variable measuring access to water is having piped water to the premise as the main source. Only one variable is related to the sanitary services: the type of toilet in the household. We devised a dummy variable that takes the value of 1 for households that have their toilets connected to the sewerage system, and 0 otherwise.

Households are classified as urban, when living in major cities, or in what DHS considers urban areas (not towns, villages, or countryside). The mother in the household is classified as married, if she is actually married or is living with her partner. Education variables for the mother of the household are also constructed given the highest schooling level completed: no education, primary, secondary, or higher education. Table 1 presents the summary statistics (proportion and averages) of all variables.

Institutional quality variables

The last source of data is based on the Colombian bureau of statistics (DANE) figures to create what we define as "quality of institutions." This term would include all government-level or social-level variables that support households in coping with conflict or, in terms of our theoretical model, reduce the effect of the war taxes on price of goods and income. The data available from 1986 to 2016, covering most of the period of the analysis, are on education (gross enrollment rate, students-to-teacher ratio, the students-to-school ratio, and the teachers-to-school ratio) and growth of GDP per capita.[10] Education indicators at the state level are used as a proxy for a better government effort in providing services that households need during conflict. Better education can also signal higher social capital and stronger social networks (Holzmann 2001), more cooperation with authorities (Fajnzylber et al. 1998) and better sanitation and hygiene, as well as better use of water resources. Finally, a state with higher GDP growth per capita offers households

[9] The Police codes the criminal events per year and per police units. Most of the police units are of state-level jurisdiction. The police units with national jurisdiction were discarded for the purpose of this paper. Data from police units with jurisdiction in the capital city of a state were added to the data of the state in which the city is located. Some police units have jurisdiction in more than one state; these units are usually located in violent regions covering bordering regions of two or more states. Information was gathered from police and military personnel to assign a weight for each of the states that have a share of its territory covered by one of these special police units.

[10] Auxiliary regressions (not reported in this paper but available upon request from the corresponding author) indicate that the education data does not seem to be impacted by any of the measures of the stock violence.

Table 1 Summary statistics of DHS variables of interest

Variable	1986	1990	1995	2000	2005	2010
Household level						
Pipped water main source of water	0.742	0.879	0.801	0.853	0.758	0.714
Water on the premise	0.809	0.952	0.912	0.952	0.938	0.946
Time to water source (minutes)	13.461	19.756	16.737	18.990	17.649	17.800
Sanitary services connected to sewerage system	0.625	0.786	0.674	0.693	0.690	0.652
Electricity in the household	0.849	0.942	0.919	0.957	0.963	0.950
Household located in urban area	0.694	0.859	0.719	0.734	0.751	0.705
Respondent always living in the sample place	0.328	0.387	0.377	0.420	0.438	0.431
Respondent with no education	0.081	0.045	0.053	0.047	0.041	0.030
Respondent with primary education	0.586	0.448	0.448	0.407	0.353	0.329
Respondent with secondary education	0.302	0.429	0.427	0.449	0.467	0.472
Respondent with higher education	0.030	0.077	0.072	0.096	0.139	0.168
Respondent currently married	0.800	0.776	0.755	0.715	0.697	0.716
Male head of household	NA	0.801	0.791	0.737	0.705	0.677
Number of households	3043	5086	7109	7825	24,241	35,126
Individual level						
Children with diarrhea	0.188	0.121	0.168	0.142	0.151	0.143
Children with fever	0.299	0.197	0.273	0.254	0.256	0.270

Source: DHS. Authors' computations

Table 2 Summary statistics of quality of institutional proxy variables (averages)

Variable	Year of the survey					
	1986	1990	1995	2000	2005	2010
GDP per capita growth	0.037	0.045	0.019	−0.039	0.013	0.014
Primary gross enrollment rate	0.933	1.044	1.059	1.145	1.163	1.103
Secondary gross enrollment rate		0.387	0.544	0.668	0.816	0.730
Primary students-to-teachers ratio	27.713	25.225	23.546	21.900	26.368	24.857
Secondary students-to-teachers ratio		18.301	19.179	16.863	24.363	20.159
Primary teachers-to-school ratio	3.604	4.057	3.724	3.586	3.311	3.226
Secondary teachers-to-school ratio		17.803	17.304	14.604	7.244	10.321
Primary students-to-school ratio	100.121	102.801	88.015	78.690	87.616	81.464
Secondary students-to-school ratio		326.635	326.365	246.704	185.738	209.031

Source: DANE. All variables computed in the year before the survey to be consistent with the armed conflict intensity data

more job opportunities, higher incomes, and better services that help cope with the violence. Summary statistics of these variables are presented in Table 2.

Empirical strategy

The following empirical model is developed based on the theoretical model and using the data from Colombia

$$\begin{aligned}\text{Indicator}_{hst} = {} & \beta_0 + \beta_1 \text{SV}_{\text{st}} + \beta_2 \text{PriStudteac}_{st-1} \\ & + \beta_3 \text{SecStudteac}_{st-1} + \beta_4 \text{Growth}_{st-1} + \gamma X_{hst} \\ & + \theta_s + \delta_t + \text{StateTrend}_{st} + \varepsilon_{hst},\end{aligned} \tag{6}$$

where the dependent variable, Indicator_{hst}, is a dummy variable taking into account whether household h in state s surveyed in year t has access either to water on the premises, to piped water, or to a toilet connected to the sewerage system. SV_{st} is the aggregated or weight-averaged for stock of violence aggregated over 1, 5, 10, or 20 years As for the institutional level variables, the quality of institutions is proxied by $\text{PriStudteac}_{st-1}$ and by $\text{SecStudteac}_{st-1}$, namely the primary and secondary education students-to-teacher ratio in the year before the survey in state s; and by Growth_{st-1}, which is the GDP growth per capita, also in the year before the survey in state s. X_{hst} represents household-level controls (related to the location). θ_s is the state-fixed effects to control for the state-level invariant features; δ_t

stands for the survey-year fixed effects to control for shocks in the year of the survey that are common to all the households. Since there might be other time-variant variables correlated with access to water and sanitation services, state-specific trends, $StateTrend_{st}$, are included in the estimations, allowing each state to have a different trend in terms of access to water and sanitation services.[11] The equation will change when testing the impact of conflict on the price of water. The impact on the price of water is going to be tested using the time to and from the water source as a dependent variable, for those households with no access to water on the premises.

It is expected, based on the theoretical model, that the coefficient of the stock of violence is of a negative sign, whether using each conflict indicator or an aggregate measure of conflict (by adding the criminal events per year per state or by principal components analysis). Terrorist attacks may delay the construction of water systems or may pollute water sources. Attacks against the police are a proxy of the vulnerability of the government in providing services. The risk of being a mass-murder victim may restrict household's access to water sources.

Access to water and sanitation services is affected by increases in kidnapping, due to the reduction in the overall economic activity as uncertainty increases. Households can no longer approach their traditional sources of water as they also fear being apprehended by the terrorist groups. Terrorist groups may extort business owners and residents through a tax on the price of goods or demanding frequent payments.

Testing Hypothesis 3 is not straightforward. When GDP growth per capita is higher, the government and households spend more on water and sanitation, and other supporting services. The situation is more complicated when it comes to the education variables. The students-to-teacher ratios provide information about the resources the government spends on providing higher quality education. In an armed conflict, the government may not have sufficient resources to improve education and access to water and sanitation services all together. In this case, an improvement in education (a reduction in teacher-to-student ratio) can only be feasible by reducing the budget available for water and sanitation services and, therefore, worsening the households' access to water. Then, the coefficients of the students-to-teacher ratios have a positive sign.

Limitations

Differences in access to water and sanitation services across states may also be explained by unobserved variables. As long as those unobserved variables are time invariant at the state level, those differences are taken care of by introducing state-fixed effects. Additionally, any invariant factor that might be related to both the internal armed conflict and the delivery of services is controlled using the state-fixed effects. If differences arise from changes that are common to all households, regardless of their state of residence in the year of the survey, those differences are purged using survey-year fixed effects.[12] The construction and development of water and sanitation infrastructure can take different paths across states, and these differences will be controlled for allowing state-specific paths[13] of access to water and sanitation services.

Access to water and sanitation involves both demand and supply sides. Regarding the demand side, it is assumed that all households have the same preferences over water and sanitation services: households would prefer higher quality water and, therefore, better sanitation facilities, as well as having the water sources as close as possible to their dwellings.

This paper focuses on access to water and sanitation services at the moment of the survey and not on its pattern over time. It is entirely possible that households experienced changes in the access to water throughout time due to civil war. Furthermore, it is possible that civil war could have forced the relocation of the household to a different state. Relocation can pose a problem for the estimation and can lead to a bias of the results. Households that otherwise would be observed after relocation with lower access to water and sanitation services in more violent states, may end up being observed in less violent states and with a higher access to water and sanitation services. However, the census data used for this paper revealed that the large majority of relocations (close to 75%) take place within the same state. This pattern of relocation reduces any possible bias created by the location decisions made by households, since violence intensity is measured at the state level.

DHS surveys households with women in reproductive age. With figures from the Colombian bureau of statistics

[11] It is entirely possible that some variables that change over time (such as pattern of urbanization, population dynamics, changes in technology, among others) have an effect on both access to water and sanitation, and the conflict intensity. Such a possibility is not ruled out in this paper. On the contrary, it is assumed that such an effect takes place at the state level at a linear fashion, and that is why, state-level specific time trends are included.

[12] Results can be interpreted as casual, as long as the fixed effects remove those variables that do not change over time and that have an impact on conflict intensity and access to water and sanitation at the state level. Fixed effects may aggravate any problem of measurement error, such as measurement error related to conflict intensity. Results have to be interpreted as a lower bound.

[13] Only linear state-specific time trends are considered in this paper. Even though non-linear state-specific time trends may take place, this remains to be explored in future research.

(DANE 2012a, b, Population series 1985–2020) for the years DHS were administered, women of reproductive age are roughly 46% of the total women population. By including this group, DHS allows focusing on the groups of women for whom access to water really makes a difference in their fertility decisions.

There might be measurement error in the conflict data. It is possible that the conflict indicators may suffer from under-reporting. It is also possible that violence is not homogeneous throughout the state. However, the theoretical model is not based on direct exposure to conflict, but on how conflict impacts a household's income and the prices of goods. As some measurement error can still be possible, the results to be presented have to be considered as a lower bound.[14] Finally, standard errors are clustered at the state level, since the stock of violence is computed for each state.

Following Miguel et al. (2004), when dealing with the exogeneity of their instrument, it is intuitively possible that violence intensity data are exogenous to the access to water and sanitation services. However, that data still have to fulfill the exclusion restriction. In the case of our paper (given the nature of the household model we developed), changes in violence intensity can only affect access to water and sanitation services through prices and income mechanisms already proposed in the paper. While other types of mechanisms are possible, for instance, if warring factions decide to control the access to natural resources, in the case of Colombia, price and income channels are the predominant impacts, since conflict led to the destruction of infrastructure, repositioning of government budget (to fund the war effort) and changes in economic activities at the local level. While it is true that rebel groups exerted some level of territorial control, such a territorial control was aimed at controlling the drug-trafficking networks and not to curtail the access to water or other natural resources. Therefore, the likelihood of endogeneity in violence and access to water and sanitation services is low and should not be a-priori considered.

Results and discussion

This section presents the results of the estimations at the household level (for access to water and sanitation measures).[15] Equations include a quadratic term for the stock of violence to take into account that civil war leaves its impact on the environment and the water systems, having an echo tail. The results from the Logit estimations report the marginal effects, which represent a net state average effect of conflict on the access to water and sanitation services.[16] It is the net effect, because the data do not allow capturing independently all the income and price effects that take place, while households make decisions. It is an average effect, due to the inclusion of state-fixed effects.

The following includes a discussion about the results. The tables present only the marginal effects of the coefficients on the conflict indicators.[17] The discussion of the results is based on the total probability change (linear plus quadratic terms of the stock of conflict).

It is relevant, at this point, to mention the main findings regarding the institutional variables included in the regressions. The secondary education students-to-teacher ratio increases the access to pipped water by 0.01% and it is significant at a 1% level in all the regressions for each conflict indicator (extorsion, terrorist attacks, kidnappings, attacks against the police, mass-murder victims, total conflict, and total conflict-factorial analysis). This result suggests that the presence of a high school facility, per se, indicates a deeper level of state presence and investment in the region, or that higher level of education can change the preference regarding water service provision.

We can also see that institutional variables are significant in the regression estimating the effect of mass-murder victims (using the 10 years aggregation and averaging) on household's time spent to and from the water source: The GDP per capita growth rate and secondary education students-to-teacher ratio have a positive coefficient; primary education students-to-teacher ratio has a negative coefficient. The largest effect by far is the one of the GDP per capita growth rate. This may posit an interesting situation in which people can afford to go farther away and, possibly, safer and better water sources over time, as they can bear the opportunity cost of fetching water.[18]

[14] The estimation does not distinguish between direct or indirect target of the violent events, whether the targets are households where the attacks took place or in neighboring places within the state.

[15] The unit of analysis is the household (the household connection to water and sanitation services), but the treatment (the intensity of the conflict) as well as the quality of institutions variables are taken at the State level. Municipality-level figures for conflict intensity are not used due to the high degree of within state migration that might invalidate the identification strategy.

[16] Generally, the R-squared is not very informative in panel data analysis. The analysis in panel data regressions relies on the significance of each individual variable as well as the overall significance of the model. In panel data, the R-square tends to be low due to heterogeneity of the various cross sections included, in our case, the states and the households. As the relevant variables are significant, as well as the overall significance of the regressions, the real problems that can be expected would be specification bias and multicollinearity. A high R-squared would be only relevant if forecasting the access to water and sanitation in the presence of conflict, but this is not the objective of the research in this paper.

[17] Tables with full results are available in Appendix 2 (of Ortiz-Correa and Dinar 2018).

[18] Individual-level regressions (available at Ortiz-Correa and Dinar, 2018) for the incidence of diarrhea and fever in children aged 5 years or younger at the households in the sample also showed contradictory

Household's access to water on premise (Table 3)

Kidnapping, aggregated or averaged over 5 years, increases the probability of having water on premises by 0.4%. Another positive relation, only around 0.6%, exists between the attacks against the police and the access to water on premises. When the risk of being kidnapped is higher and the police is under attack and cannot provide safety to the citizens, households will invest in getting the water inside their dwellings to avoid being targeted by violence while searching for water outside their premises.

Household's access to piped water (Table 4)

The aggregation of extortions over 20 years reduces the probability of access to piped water by 7.7%. Another negative relationship is found with the number of mass-murder victims. Aggregating or averaging mass-murder victims over 5 and 10 years reduces access to piped water by 2% and 9%, respectively. By increasing prices or reducing the households' incomes, extortion makes it difficult for the households to afford having access to piped water. The effect through the number of mass-murder victims may indicate that massacres bring such a disruption in the functioning of the society that the government and the water utilities cannot provide water services or cannot extend the water systems.

Household's access to toilet connected to the sewerage system (Table 5)

The number of terrorist attacks aggregated over 20 years before the survey increases by 10% the probability of connection to the sewerage system but reduces it by 20% when using the 10% weighted average procedure. When attacks against the police are aggregated for 10 years, there is a 16% higher probability of connection. One explanation is that the government and the households have internalized the effect of terrorism: governments rebuild the sewerage network or expand the service, and households adapt by moving to a different service.

Households' time spent to and from the water source (Table 6)

Kidnapping events 1 year before the survey reduce the time spent by 1.5 min. However, when the figures of kidnappings are aggregated for 10 and 20 years, they increase the time spent by 1.6 min and up to 4.3 min, respectively. Households may react by changing the water sources to closer ones, but may resort again to further water sources after processing the information about the likelihood of being kidnapped by terrorist groups. Paradoxically, the attacks against the police increase the time spent by 5 min. The 5- and 10-year aggregations of the attacks against the police reduce it by 4 min. Families may be forced to substitute water sources and they may go to sources that are away from locations where police are clashing with the terrorist groups. The coefficients skyrocket for the 10-year aggregation and averaging of mass-murder victims. Households may prefer to spend less time in getting the water they need rather than being around water sources where they can be victimized. This is particularly relevant, if women and children are responsible to haul the water from the water source.

Robustness checks

This strategy assumes that the whole process of violent conflict, operating jointly through the different types of offenses, is the one causing the negative externalities for the environment and the households. A variable named "total conflict" was computed by adding all the offense incidents per state per year, assuming an equal impact for each. It then applies the proposed 1-, 5-, 10-, and 20-year aggregation or weighted average (10% and 20% growing weights). Since it is not clear how the aggregation process works, and since the five measures of conflict are correlated, a principal component analysis (PCA) was applied.

The coefficients suggest that total conflict and total conflict-factorial (calculated as PCA) increase the probability of having water on premise by 0.5%. A sign switch occurs for the time spent traveling to and from the water source: the total conflict measures during the previous year translates into a 1.4-min reduction in the time the household spends, but the total conflict during the previous 20 years increases the time by 2.8 min. The factorial measure of the conflict aggregation results in a 9-min increase, but a 16-min and 42-min reduction in time spent when the aggregation is made for 10 and 20 years before the survey, respectively. All these values may hide a trade-off between quantity and quality, with households preferring closer, and lower quality, water sources.

Footnote 18 (continued)

signs on the coefficients of the institutional variables. For instance, GDP per capita growth rate increases the probability of diarrhea in the regressions for extortions, terrorist attacks, kidnappings, and attacks against the police. However, there is an opposite sign and the same indicator reduces the incidence of diarrhea in the regression for mass-murder victims. Although a higher GDP implies that households have more resources to cope with conflict and to offer better food and better health care to their children, it can also be true that conflict causes higher disruptions when households are more economically included. The secondary education students-to-teacher ratios are positively related to the incidence of fever, which suggest that there is a higher exposure to pathogens and contagion as more children go to school and reside in the same classroom.

Table 3 Effect of conflict on household's access to water on premises

Conflict indicator	Regression information	Aggregation				Averaging η = 0.1			Averaging η = 0.2		
		1 year	5 years	10 years	20 years	5 years	10 years	20 years	5 years	10 years	20 years
Kidnappings	Linear	0.001	0.003**	−0.001	0	0.004***	−0.001	0.002	0.003***	−0.001	0.002
		(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)	(0.002)
	Quadratic	0	0**	0	0	0***	0	0	0**	0	0
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Observations	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464
	R-squared	0.305	0.312	0.306	0.3038	0.3125	0.3046	0.3041	0.3117	0.3038	0.3044
Attacks against the police	Linear	0.006***	−0.002	0.045*		−0.003	−0.005		−0.003	−0.006*	
		(0.002)	(0.003)	(0.022)		(0.004)	(0.003)		(0.004)	(0.003)	
	Quadratic	0***	6.97e−06	−0.011*		4.97e−06	0		0	0	
		(0.000)	(0.000)	(0.005)		(0.000)	(0.000)		(0.000)	(0.000)	
	Observations	77,464	73,225	66,116		73,225	66,116		73,225	66,116	
	R-squared	0.3124	0.2998	0.3196		0.3006	0.2857		0.3014	0.2867	
Total conflict	Linear	0.002*	0.001*	0	0	0.002**	0	0.001	0.002*	0	0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Quadratic	0	0**	0	−8.68e−06	0**	−5.09e−06**	0	0**	−5.42e−06	0
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Observations	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464
	R-squared	0,3089	0,3081	0,3055	0,3038	0,3082	0,3042	0,3041	0,3079	0,3039	0,3044
Total conflict (factorial)	Linear	0.008*	0.011**	−0.004	0.004	0.012**	−0.002	0.007	0.012**	0.001	0.007
		(0.004)	(0.005)	(0.004)	(0.006)	(0.006)	(0.006)	(0.008)	(0.005)	(0.007)	(0.008)
	Quadratic	−0.003*	−0.001**	−0.001	0	−0.001**	0	−0.001	−0.001**	0	−0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Observations	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464	77,464
	R-Squared	0.3087	0.3086	0.3057	0.3041	0.3088	0.3044	0.3043	0.3085	0.3039	0.3045

Robust standard errors in parentheses clustered at the state level (33 states). *Significant at 10%; **significant at 5%; ***significant at 1%. Regressions include state-specific trend and survey-year fixed effects. Conflict indicators per 100,000 inhabitants averaged or aggregated as explained in the data sources section

Table 4 Effect of conflict on household's access to piped water

Conflict indicator	Regression information	Aggregation				Averaging η = 0.1			Averaging η = 0.2		
		1 year	5 years	10 years	20 years	5 years	10 years	20 years	5 years	10 years	20 years
Extortion	Linear	−0.127	−0.153	0.002	−0.775**	−0.168	−0.066	−0.39	−0.178	−0.121	−0.238
		(0.122)	(0.169)	(0.159)	(0.370)	(0.172)	(0.158)	(0.245)	(0.173)	(0.172)	(0.210)
	Quadratic	0.141	0.199	−0.092	0.56	0.214	0.024	0.191	0.222	0.117	0.181
		(0.118)	(0.209)	(0.142)	(0.408)	(0.204)	(0.163)	(0.239)	(0.197)	(0.203)	(0.235)
	Observations	81,470	81,470	81,470	81,470	81,470	81,470	81,470	81,470	81,470	81,470
	R-squared	0.3342	0.3342	0.334	0.3357	0.3342	0.334	0.3347	0.3343	0.334	0.3342
Attacks against the police	Linear	0.031***	−0.015	0.265*		−0.017	−0.023		−0.016	−0.032	
		(0.011)	(0.016)	(0.154)		(0.018)	(0.028)		(0.019)	(0.026)	
	Quadratic	−0.002***	0.001	−0.045		0.001	0.001		0.001	0.001	
		(0.001)	(0.001)	(0.041)		(0.001)	(0.001)		(0.001)	(0.001)	
	Observations	81,470	77,000	69,513		77,000	69,513		77,000	69,513	
	R- squared	0.3372	0.3309	0.3239		0.3309	0.3266		0.3309	0.3267	
Mass murder victims	Linear	0.026	−0.046***	−0.09		−0.048**	−0.113***		−0.049**	−0.118***	
		(0.025)	(0.019)	(0.058)		(0.019)	(0.039)		(0.020)	(0.032)	
	Quadratic	−0.004	0.007***	0.011*		0.007***	0.014***		0.008***	0.015***	
		(0.004)	(0.002)	(0.006)		(0.003)	(0.004)		(0.003)	(0.004)	
	Observations	77,000	69,513	61,685		69,513	61,685		69,513	61,685	
	R-squared	0.3311	0.3277	0.3253		0.3278	0.3263		0.3278	0.3269	

Robust standard errors in parentheses clustered at the state level (33 states). *Significant at 10%; **significant at 5%; ***significant at 1%. Regressions include state-specific trend and survey-year fixed effects. Conflict indicators per 100,000 inhabitants averaged or aggregated as explained in the data sources section

Table 5 Effect of conflict on household's toilet connected to the sewerage system

Conflict indicator	Regression information	Aggregation				Averaging η = 0.1			Averaging η = 0.2		
		1 year	5 years	10 years	20 years	5 years	10 years	20 years	5 years	10 years	20 years
Terrorist attacks	Linear	0.015	0.009	0.034	0.163*	0.009	0.023	0.107**	0.009	0.017	
		(0.026)	(0.029)	(0.025)	(0.094)	(0.028)	(0.027)	(0.052)	(0.028)	(0.027)	
	Quadratic	0.000	0.000	−0.003	−0.024**	0.000	−0.002	−0.011**	0.000	−0.001	
		(0.002)	(0.003)	(0.002)	(0.011)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	
	Observations	81,491	81,491	81,491	81,491	81,491	81,491	81,491	81,491	81,491	
	R-squared	0.4617	0.4616	0.4615	0.4622	0.4616	0.4615	0.4619	0.4615	0.4615	
Attacks against the police	Linear	0.031	−0.083	−0.349***		−0.071	0.079		−0.061	0.031	
		(0.054)	(0.112)	(0.027)		(0.115)	(0.339)		(0.115)	(0.269)	
	Quadratic	−0.002	0.044*	0.381***		0.041	0.045		0.040	0.045	
		(0.003)	(0.024)	(0.013)		(0.024)	(0.057)		(0.025)	(0.047)	
	Observations	81,491	77,009	69,511		77,009	69,511		77,009	69,511	
	R-squared	0.4616	0.4613	0.4599		0.4614	0.4519		0.4614	0.4520	

Robust standard errors in parentheses clustered at the state level (33 states). *Significant at 10%; ** significant at 5%; *** significant at 1%. Regressions include state-specific trend and survey-year fixed effects. Conflict indicators per 100,000 inhabitants averaged or aggregated as explained in the data sources section

Conclusion and policy implications

Using the Colombian civil war as a case study, the main results of our analysis indicate that the effect of civil war is significant and its sign, whether negative or positive, depends on the length of the aggregated or averaged civil war (or violence) indicators. Furthermore, the relationship is not linear. Significant squared terms are found for most of the estimations.[19] With respect to the hypotheses, it can be said that civil war does reduce the access to water and sanitation services[20]; however, there is evidence of some positive effects that ought to be interpreted as the result of households' strategic behavior and adaptation to the reality imposed by the civil war. The up-to 9-min increase in the time households have to spend to and from the water sources points out to an increase in opportunity cost. Assuming that, on average, individuals can work nearly 9600 min a month (40 h per week) and that households may need to get water at least three times a week, the effect of civil war represents 27 more minutes a week or 108 min a month, which has a labor equivalent value of 1.12% of the monthly working minutes. Such a difference could be considerable for the poorer households and in a context of rapid price changes. Additionally, given that the change in the quality of water is not directly controlled, it can only be assumed that the exposure to lower quality water forces the household to reallocate additional financial resources for disinfection.

[19] Since the Colombian conflict has not been initiated or driven by lack or scarcity of water and sanitation services, the estimations do not suffer from reversed causality. For instance, it is not the case that the lack of access to water and sanitation services obliges households to kill, to kidnap or to carry out terrorist attacks.

[20] Regressions (not presented here, but available at Ortiz-Correa and Dinar 2018) using the children aged 5 years or younger of the households in the sample indicate that armed conflict harms the health of children. Two variables related to health are available in the DHS: incidence of fever and incidence of diarrhea. The relationship between these infectious diseases and the conflict indicators seems to depend on the type of conflict indicator and the length of the conflict data considered. For the incidence of diarrhea, the number of the extortions in the year before the survey increases the likelihood of diarrhea by 7.4%. However, when aggregating the number of extortions over 10 years, the probability is reduced by 10%. The terrorist attacks in the year before the survey reduced the probability of diarrhea by 1%. The 10 year averaging of attacks against the police also reduced the probability by 11% and 8%, for 10% and 20% averaging. In relation to the incidence of fever, the aggregation or averaging of the terrorist attacks for 5 and 10 years reports an increase of the fever probability around 2%. The number of mass-murder victims in the year before the survey reduces the probability of fever (close to 3%), but the aggregation for 5 and 10 years consistently increases it up to 19%. Overall, the differences in sign and in magnitudes can be an indication of how households may react to different conflict intensity information and (for instance, adjusting the time for parental supervision) and how they can help their children cope with the post-traumatic stress disorder (Nersisyan 2006).

Table 6 Effect of conflict on household's time spent to and from water source

Conflict indicator	Regression information	Aggregation				Averaging η = 0.1			Averaging η = 0.2		
		1 year	5 years	10 years	20 years	5 years	10 years	20 years	5 years	10 years	20 years
Kidnappings	Linear	−1.850***	0.574	1.832**	5.110**	0.604	1.617	2.901*	0.341	1.032	1.346
		(0.509)	(0.591)	(0.896)	(2.148)	(0.729)	(1.015)	(1.757)	(0.730)	(0.958)	(1.235)
	Quadratic	0.119***	−0.024	−0.060**	−0.284***	−0.025	−0.053*	−0.110**	−0.016	−0.037	−0.051
		(0.024)	(0.018)	(0.024)	(0.087)	(0.024)	(0.029)	(0.055)	(0.025)	(0.029)	(0.039)
	Observations	4674	4674	4674	4674	4674	4674	4674	4674	4674	4674
	R-squared	0.0013	0.0004	0.0004	0.0001	0.0005	0.0003	0.0002	0.0001	0.0000	0.0000
Attacks against the police	Linear	−3.080	9.571**	11.356**		7.773*	23.865*		6.285	19.503*	
		(2.775)	(4.378)	(5.051)		(4.643)	(13.096)		(4.895)	(9.983)	
	Quadratic	0.106	−4.065***	−11.300***		−3.571***	−7.588**		−3.163***	−6.544***	
		(0.162)	(1.070)	(2.082)		(1.067)	(2.973)		(1.090)	(2.250)	
	Observations	4674	4457	3827		4457	3827		4457	3827	
	R-squared	0.0074	0.0045	0.0004		0.0047	0.0062		0.0052	0.0058	
Total conflict	Linear	−1.868***	0.108	0.907	3.796**	−0.110	0.531	1.501	−0.415	0.087	0.385
		(0.634)	(0.501)	(0.750)	(1.806)	(0.574)	(0.804)	(1.386)	(0.582)	(0.739)	(0.965)
	Quadratic	0.082***	−0.003	−0.022	−0.143**	0.005	−0.013	−0.043	0.016	−0.000	−0.010
		(0.028)	(0.014)	(0.018)	(0.060)	(0.017)	(0.020)	(0.036)	(0.018)	(0.020)	(0.027)
	Observations	4674	4674	4674	4674	4674	4674	4674	4674	4674	4674
	R-squared	0.0054	0.0001	0.0002	0.0001	0.0000	0.0001	0.0005	0.0002	0.0000	0.0001

Robust standard errors in parentheses clustered at the state level (33 states). *Significant at 10%; ** significant at 5%; *** significant at 1%. Regressions include state-specific trend and survey-year fixed effects. Conflict indicators per 100,000 inhabitants averaged or aggregated as explained in the data sources section

Additionally, the results provide evidence for the important role of the institutional variables in the regressions. While some of the institutional results might be counterintuitive, their significance in several of the regressions points out to a more complex phenomenon of households' reliance on safety nets, and to the level of government presence in the regions. All in all these results indicate higher extent of public investment, access to public services and the multiplier effect of economic activity.

As part of the strategy to win hearts and minds during civil war, governments could invest in the maintenance of water systems in pacified areas or in areas that can be receiving refugees; they could also deliver tank trucks that distribute water where needed and could implement health brigades or distribute nutrition supplements, targeting children and their caretakers. After signing the peace agreements between the government of Colombia and the FARC, the reconstruction efforts did not include a particular focus on water or sanitation services. However, the peace obligations included some commitments (land reform, territorial development, and protection of natural resources) that with the reformed state-level water plans and the increased resources for sustainable cities and housing in the country, are aimed at guaranteeing the universal access to water and sanitation services as a priority of the reconstruction efforts.

Future research needs to use panel data at the household level, as well as other methods for aggregations or averaging various civil war indicators to offer a more complete picture of the household's strategic behavior. Furthermore, research should address the problem of the institutional variables at the community or extended-family level.

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