Agricultural Production amidst Conflict: The Effects of Shocks, Uncertainty and Governance of Non-State Armed Actors*

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This version: October 23, 2013

Abstract

This paper examines the effect of conflict on agricultural production of small-farmers. First, we develop an intertemporal model of agricultural production in which the impact of conflict is transmitted through two channels: violent shocks and uncertainty brought by conflict. The model shows how conflict induces sub-optimal agricultural decisions in terms of land use and investment. We test the model using a unique household survey applied to 4.800 households in four micro-regions of Colombia. The survey collects detailed information on households' economic conditions, incidence of violent shocks, and presence of non-state armed actors. The results show conflict affects agricultural production through different channels. In regions with an intense conflict, households reduce land allocated to perennial crops, increase production of seasonal crops and pasture, and cut back investments. Households seem to learn to live amidst conflict. Recent presence of non-state armed actors induces farmers to cut-back strongly land use on perennial crops, pasture and investments. As presence is more prolonged, farmer increase land use on perennial crops and pasture, and investments rebound. However, total agricultural production might be lower because shocks and presence result in more land being idle land. Households habituate to conflict, yet in a lower equilibrium.

Key Words: Conflict, uncertainty, agricultural production, small-farmers, developing economies

JEL Codes: D13, D74, Q1

* The authors are graduate student at University of Chicago, and associate and assistant professor at Universidad de Los Andes in Colombia, respectively. We gratefully acknowledge funding from UKaid from the Department for International Development- DFID/ESRC. Adriana Camacho, Andrés Moya, Steven Raphael, Juan Fernando Vargas and participants in the HiCN annual workshop, CEDE, ABCDE Conference, Al CAPONE Universidad del Rosario, LACEA and ICESI, provided valuable comments in the improvement of this paper. Any remaining mistakes in the paper are our own.

1. Introduction

Conflicts impose costs on economic production through two broad channels. First, aggressions and attacks during conflicts cause devastation and limit market transactions. Second, the presence of non-state armed actors pushes households to modify behavior in spite of not facing violent shocks. Studies on the economic literature concentrate mostly on the impact of violent shocks during conflict (Blattman and Miguel 2010). However, these two channels are far from being perfectly correlated, thus papers focusing in the first channel underestimate the total effect of conflict. The purpose of this paper is to identify and separate how conflict affects household behavior through: (i) violent shocks; and (ii) the uncertainty and fear brought by conflict (henceforth uncertainty).

Evidence on the first channel is ample. Armed combats, terrorist attacks, looting or overall devastation generate the destruction of public and private capital, and assets thereby decreasing the productive capacity of firms and households (Blattman and Miguel 2010; Ibáñez and Moya 2010; Justino 2011). Aggressions against the civil population destroy or deteriorate human capital through abductions, killings and maiming (De Walque 2006; Camacho 2008; Walque and Verwimp 2009; Verwimp, Bundervoet et al. 2010). These violent shocks also reduce market efficiency. Contraction in the supply of goods, and higher transactions costs cause prices increases, and reductions in the size of networks (Deininger 2003; Justino 2011). All these effects produce a drop in households' income and consumption, and countries experience a fall in the aggregate production (Abadie and Gardeazabal 2003; Brück 2004; Justino and Verwimp 2006). Findings also show that conflict negatively affects economic performance, but countries and households may quickly recover from devastation if a threshold of destruction is not surpassed (Murdoch and Sandler 2002; Abadie and Gardeazabal 2003; Justino and Verwimp 2006; Nillesen and Verwimp 2010; Akresh, Verwimp et al. 2011)

However, conflict imposes costs beyond destruction. Violence increases uncertainty and risks (Rockmore 2011). In addition, non-state actors may impose governance structures in the regions they control by enforcing rules of conduct, taxing households and production, obliging households to grow certain crops (i.e. illegal crops), and favoring some groups over others (Kalyvas 2006; Justino 2011). In spite of not facing violent shocks, households

adjust their behavior in anticipation of a conflict induced-shock, to avoid being targeted, to minimize potential losses after an attack or to abide rules imposed by non-state armed actors. These adjustments seek to minimize conflict risks, and not to maximize profits (Verpoorten 2009).

Identifying the strategies households adopt to confront conflict, despite not facing direct violent shocks, is important for three reasons. First, the bulk of the population is not directly affected by violent shocks, but a large proportion modifies their behavior in response to the violent context in which they live. This is particularly relevant for countries facing long-lasting low or medium intensity conflicts. Second, households learn to live amidst conflict and change their behavior in subtle ways. These costs are largely unaccounted for in current studies and might be large. Third, once the conflict ends, households may remain entrenched in the low risk strategies adopted during the conflict, preventing them from reaping the benefits of peace. Thus, income may not necessarily recover entirely in a post-conflict period for many households.

To provide intuition on how conflict distorts agricultural decisions, we first propose a model where a farmer living in autarky decides whether to invest in perennial or seasonal crops and how much to invest. It is assumed that perennial crops need higher investment to be more productive than seasonal ones. Each period the farmer is hit by a violent shock that decreases production. The violent shock could arise from a permanent or a transitory distribution, where the former implies that shocks tend to be worse. However, the farmer is uncertain of the nature of the shock and assigns a belief to each distribution. The belief represents the uncertainty faced by the farmer, which is updated once a shock is observed.

The model predicts that farmers prefer to invest in seasonal crops when facing more negative violent shocks and when beliefs are biased toward the permanent shocks. But since seasonal crops are less profitable, farmers are driven to a low income equilibrium. On the other hand, if farmers are sufficiently risk averse, a violent shock has a nonlinear effect on investment. If uncertainty is low, the effect is negative since productivity is lower; but when uncertainty increases, the effect could be positive since farmer will update his belief towards the permanent distribution where more investment is used for self-insurance.

We then test the hypothesis derived from the model using a unique data set for Colombia, a country that has experienced a long-standing conflict for over fifty years. We designed a household survey to collect detailed information on the dynamics of conflict such as the occurrence of violent shocks, historic presence of armed groups, and the governance structure they impose upon the population. This unique data set allows us to examine and separate the impact of conflict through violent shocks and uncertainty, measured as years of presence of non-state armed actors. Our paper intends to understand whether conflict has an effect on household behavior beyond the impact of conflict-induced shocks. We concentrate the analysis on households' decisions related to agricultural production such as land use, and investments.

Estimating a causal relation between violent shocks and armed group presence, on the one hand, and agricultural decisions, on the other, is difficult. Armed groups do not randomly locate themselves across the territory. Non-state actors establish their presence on regions with particular geographical and institutional characteristics that favor their war objectives. Incidence of covariate shocks is not random either. Non-state actors attack certain groups of the population to illegally seize assets, strengthen territorial control, or prevent future civil resistance (Azam and Hoeffler 2002; Engel and Ibáñez 2007). In order to correct for this endogeneity, we use a spatial discontinuity strategy similar to Acemoglu et al (2012), Naidu (2012) and Dube et al (2010). We create pair of contiguous districts one with presence of non-state armed groups and the other without. Unobservables that jointly determine armed group presence and agricultural decisions vary smoothly across districts and are potential sources of bias. Our identification strategy controls for these unobservable by including fixed effects for each contiguous pair. We also include a rich set of geographic, household, land plot, rural district and municipality controls that may also determine presence of non-state armed actors or incidence of violent shocks.

Results of this paper show that conflict affect land use and investment beyond violent shocks. Conflict shocks induce households to reduce land allocated to perennial crops, and increase use to pasture and seasonal crops. Total production may decrease as the percentage of idle land is higher and overall investment falls. Nonetheless, households appear to habituate somehow to presence of non-state armed actors. During the initial years of armed

group presence, farmers cut back production on perennial crops and pasture. As presence is more prolonged, households gradually adjust their behavior and increase again perennial crops, pasture and overall investment. Households adjust decisions such to re-optimize investment decisions.

The policy implications from our paper complement those of current studies who underestimate the economic consequences of conflict. We argue that policies in post-conflict periods should concentrate beyond reconstruction efforts. In order to ensure a long-term recovery and sustainable post-conflict, policies should incentive households to separate from sub-optimal decisions adopted during conflict.

1.1 Literature Review

Recent research provides examples on how households modify productive decisions to reduce conflict risks. First, small agricultural producers change their cattle portfolio (Verpoorten 2009). Cattle are difficult to conceal, and signal household wealth to non-state actors, which increases the likelihood of being targeted. Conversely, cattle can be easily sold, providing financial resources to households in times of need. Verpoorten (2009) finds the second effect dominates in Rwanda: cattle sales increase in war time to smooth household consumption. Sales are particularly responsive to covariate violent shocks vis-à-vis idiosyncratic ones.

Second, households shift income sources to protect consumption. In Mozambique, farmers relied more on subsistence activities, and reduced participation in markets activities. By shunning out of markets, households protected food consumption and their income. Weak labor markets intensified these effects because opportunities on off-farm work were scarce (Bozzoli and Brück 2009). Households also recur to income activities that are less sensible to conflict. Deininger (2003) finds that war increased start-ups in non-agricultural activities in Uganda.

Third, conflict induce adjustments in investment decisions though several channels. Households may save more as future income becomes increasingly uncertain (Verpoorten 2009). In addition, expected returns on assets change. Risk of attacks, and subsequent forced migration, imply that mobile assets are more valuable in conflict regions (Grun

2008). Because assets signal household wealth and some are difficult to conceal, assets may become liabilities (Engel and Ibáñez 2007; Rockmore 2011). Empirical findings show that conflict induces households to reduce the share of fixed assets and to increase the share of mobile assets, and reduces investment overall (Deininger 2003; Grun 2008).

Since these adjustments in behavior seek to minimize conflict risk, households adopt sub-optimal production decisions. Households living in conflict regions may produce less, earn lower profits, and face higher costs, despite not being direct victims of conflict induced-shocks. These sub-optimal strategies may persist after the conflict ends. In Mozambique, three years after the cease fire, households were still practicing many of the their war time coping strategies (Bozzoli and Brück 2009).

The lack of detailed data on conflict dynamics limits the contributions of the papers discussed above. These papers explore potential adjustments in behavior in response to conflict, yet conflict is measured as the incidence of violent shocks. These papers assume that the coefficient for the incidence of idiosyncratic or covariate shocks captures losses from violent shocks and uncertainty, if these are correlated. However, conflict dynamics are complex. Kalyvas (2006) shows that, in regions in which non-state armed actors exercise a strong regional control, violence against civilians is lower or practically non-existent. Thus, the coefficient for conflict-induced shocks only captures a fraction of the economic losses from conflict. These costs, such as destruction and devastation of private assets and public infrastructure, are more easily recovered once conflict ends (Blattman and Miguel 2010).

A noteworthy exception is Rockmore (2011) who separates the impact of conflict on the risk of violence and the exposure to violence. The paper separates risk into objective and subjective risk. The author measures objective risk as attacks against the community in the previous year, and subjective risk with perceptions of survey respondents on difficulties to cultivate land due to insecurity. Both risks are predicted using the distance of the community to attacks of armed groups in previous years and household controls. His estimates show subjective risk has a higher impact than objective risk on household consumption. In fact, half of welfare losses caused by conflict are related to risk and not to direct exposure to violence.

We depart from Rockmore's (2011) approach in several ways. First, both measures of risks in his paper only uses attacks to capture conflict dynamics, yet uncertainty may arise also if attacks and aggressions are not taking place. Instead, we use objective data on presence of armed groups and relate it to subjective beliefs through our model. Second, the impact of risk of violence might be highly non-linear. At initial periods, households may react abruptly to presence of non-state actors, and incidence of shocks. Once non-state actors stay for a long period, households may habituate to their presence, and reactions are less abrupt or may converge to a low-income equilibrium, but with low risk of being victimized. Third, we focus on production decisions rather than consumption.

The structure of the paper is as follows. Section two provides a brief summary of the Colombian conflict. Section three develops a theoretical model that includes the effect of both violent shocks and uncertainty on decisions taken by a small farmer. In section four, we describe the data and the empirical strategy, and discuss the results. Section five concludes.

2. Conflict in Colombia

During the twentieth century, Colombia faced two conflicts. The first conflict started in 1948 after the assassination of Jorge Eliécer Gaitán, the presidential candidate from the *Liberal* party. During this period, named *La Violencia*, violent disputes between the two traditional political parties (*Liberal* and *Conservador*) originated the conflict. Near 200,000 people died in the period ranging from 1948 and 1953 (Guzmán, Fals-Borda et al. 1963; Sánchez and Meertens 2001). In 1953, a military dictatorship, headed by General Rojas Pinilla, overthrew the democratic government and provided an amnesty to the liberal guerrillas. The dictatorship lasted five years. Democracy returned after the two traditional parties brokered a power sharing agreement that lasted from 1958 till 1974.

The power sharing agreement significantly reduced violence, yet the structural causes that fueled *La Violencia* were unresolved. Income inequality, a weak state unable to establish presence in many regions of the country, uncertain property rights over land, and a pervasive land distribution remained dormant in many regions of the country. In addition, this agreement excluded participation in the electoral arena for other political groups. New left-wing guerrilla groups, namely ELN and FARC, appeared during the 1960s. The groups

aimed to overthrow the government and advocated for an aggressive agrarian reform. During the first two decades, these guerrilla groups were small, controlled isolated regions of the country and launched sporadic attacks. By the end of the seventies, guerrilla groups modified their strategy in order to collect monetary resources to fund war strategies. Kidnappings, cattle theft and extortions against landowners and drug dealers intensified in many regions of the country.

Right-wing paramilitary groups were created during the 1980s. Several factors contributed to the emergence of these groups. First, the appearance of illegal drugs provided financial resources that strengthened left-wing guerrilla groups but also fostered the creation of vigilante groups, which were created by drug-dealers and local landlords as a response to kidnappings, cattle theft, and extortions (Verdad Abierta, 2011)[1]. Second, failed peace negotiations with guerrilla groups in 1982 and 1986 led to the appearance of these groups to protect the civil population against aggressions from guerrilla groups (Romero 2002). Third, land owners in several regions of the country created vigilante groups of less than 1.000 men to protect their properties and agricultural production (Duncan 2005; Duncan 2006). Initially, these groups were organized to defend land barons and drug dealers, yet in 1997 vigilante groups merged under the *Autodefensas Unidas de Colombia* (AUC) to contest the territories dominated by the guerrillas and to launch attacks in strategic regions to further their war objectives.

The rise of paramilitary groups and the monetary resources from illegal drug trade contributed significantly to fuel the conflict and to its geographical expansion. Attacks against the civil population from guerrillas and paramilitaries heightened, leading to massacres, selective homicides, death threats and massive forced displacement. According to the Official Group of Historical Memory (2013), for the period ranging from 1985 till March of 2013, more than 166 thousand people died due to conflict, 1,982 massacres were perpetrated by non-state armed actors, and 8.3 millions of hectares were illegally seized. Today, 3.9 million people, equivalent to 8.4 percent of the population have been forced to migrate[2].

[1] www.verdadabierta.com retrieved on the 7th of July, 2012
[2] www.accionsocial.gov.co retrieved on the 15th of July, 2012.

Non-state armed actors consolidated significantly during this period. While in 1978, the FARC had seven fronts and 850 combatants, in 2000 these figures increased to 66 fronts and 16.000 combatants. The ELN increased to 4.500 combatants in 2000 from 350 in 1984 (Sánchez, Díaz et al. 2003). In 1993, the AUC had 1.200 combatants, which increased to 10.000 in 2002 (Echandía 2006).

From 2002 onwards, the conflict eased. Massive financial resources provided to the State Armed Forces, and a peace process with paramilitary groups between 2003 and 2006 contributed to reduce violence. This lead to 38 collective demobilizations, equivalent to 31.767 combatants (Valencia 2007). However, the scope of the demobilization process was limited as some groups did not demobilize and others preserved their warring structures. The groups mutated to smaller drug-dealer bands, named BACRIM (Criminal Bands, for its Spanish Acronym), scattered around the country. In 2009, 82 criminal groups with an estimated of 5.000 combatants were exercising presence in 273 municipalities (Fundación Nuevo Arco Iris, 2009[3]). On the other hand, guerrilla groups are still operating in several regions of the country.

3. Model

According to the previous literature review, we propose a model that separates the impact of conflict on violent shocks and uncertainty. The model features a small farmer that lives in autarky and each period decides whether to invest in perennial or seasonal crops and how much to invest. Perennial crops are characterized by large investments in order to be more productive than the seasonal ones. The violent shock is included as a multiplicative shock to the production function and it represents the amount of production that is left to the farmer after the shock. We assume farmers are uncertain of whether the shocks are permanent or transitory. Shocks are assumed to be permanent when the non-state armed actor is hegemonic in the region, whereas they are assumed transitory if the government is

[3] http://www.verdadabierta.com/component/content/article/50-rearmados/1520-narcotrafico-extorsion-sicariato-y-robo-de-tierras-tendrian-afectados-a-25-departamentos-el-tiempo retrieved on the 7th of July, 2012.

the hegemonic one. The uncertainty caused by conflict is included through the beliefs that farmers have about the distribution of the shocks. [4]

The model predicts that farmers prefer to invest in seasonal crops when facing more negative violent shocks and when beliefs are biased toward the permanent shocks. Although seasonal crops are less risky when facing high intensity violent shocks, they are also less profitable; thus farmers are driven to a low income equilibrium. Moreover, if farmers are sufficiently risk averse, they prefer to invest more when facing permanent shocks as a self-insurance strategy. Therefore, a higher violent shock has two opposite effects: it decreases investment since the shock lowers its productivity, but it also increases investment since a more negative shock leads to a belief updating towards the permanent distribution. The second effect vanishes as uncertainty over the distribution diminishes, that is when the farmer is almost sure of the type of shock distribution she is facing and there is little room for updating.

Consider an infinitely lived farmer who maximizes his discounted intertemporal utility $\sum_{t=0}^{\infty} \beta^t u(c_t)$, where c_t is the consumption at time t, $\beta \in (0,1)$ is the discount factor, and $u(\cdot)$ is an increasing and concave function. Each period *t*, the farmer decides whether to invest in seasonal or perennial crops, $i \in \{s, p\}$ and how much to invest k, before observing the violent shock z. After the shock is realized, the amount $z_t f_i(k_t)$ is produced.[5] We assume that both production functions are increasing and concave, and that the marginal productivity is always higher for the perennial crops $f_p'(\cdot) > f_s'(\cdot)$, although for lower investments $f_p(\cdot) < f_s(\cdot)$. In other words, we assume the single crossing property holds. For simplicity on notation, we assume that there is full depreciation of the capital in each period; however, all the results presented here will hold without this assumption. Each

[4] The model will not consider any strategic interaction with the non-state armed actors, the unique interaction is through the shocks. Although farmers may take decisions to decrease their vulnerability to the non-state armed actors, we abstract from modeling the decisions taken by the non-state armed groups. Our aim is to generate testable predictions on the farmers' decisions, and empirically we deal with the endogeneity that arises from the strategic interaction. Similarly we do not model market interactions that can generate general equilibrium effects, but we control for them in the empirical strategy.

[5] The shock can also capture losses on human capital, labor, or other production factors. Just assume that these factors enter multiplicatively with respect to the capital, thus reductions in these factors can be represented as a multiplicative shock.

period, production is distributed between consumption c_t and investment on capital for next period's production k_{t+1}.

Violent shocks can arise from two possible distributions. When the non-state armed actor is hegemonic in the region, we will say that shocks are permanent and are distributed according to the c.d.f. $G(z)$ with p.d.f. $g(z)$. When this is not the case, we will say that shocks are transitory and are distributed with c.d.f. $H(z)$ and p.d.f. $h(z)$.

We assume that $H(z)$ dominates $G(z)$ in the monotone likelihood ratio (MLR) order. This implies that the more negative is the shock, the more likely it was drawn from the permanent distribution rather than the transitory one. In this context, it implies that larger violent shocks are more likely to arise in regions where the non-state armed actor is hegemonic. The MLR dominance also generates first order stochastic dominance (Athey 2002). Hence, the expectation of monotone functions with respect to the shock is greater when shocks are transitory. This implies that farmers in regions where non-state armed actors are hegemonic are worse off.

As the evidence suggests, we will let the farmer be uncertain about the nature of the shocks. The farmer believes with probability q_t that shocks are permanent and with probability $1 - q_t$ that shocks are transitory. When the farmer faces a shock z_t, she updates this belief using Bayes rule. Given our dominance assumption on the distributions, a larger negative shock induces a larger posterior q_{t+1}. Note that the model includes both risk, through z, and ambiguity, through q. However, although there is risk aversion, we assume for the sake of simplicity that the individual is ambiguity neutral.[6]

The problem can be expressed recursively as:

$$v(i,k,q,z) = \max_{c,k',i'} u(c) + \beta\left[q' \int v(i',k',q',z')dG(z') + (1-q')\int v(i',k',q',z')dH(z')\right]$$

subject to $c + k' = zf_i(k)$ and $q' = \frac{g(z)q}{g(z)q + h(z)(1-q)}$

[6] Results will hold if we assume ambiguity aversion. As we note below, the key predictions are obtained for sufficiently risk averse agents. In this sense, ambiguity aversion will make our predictions stronger.

Note that the choice on which crop to use depends on its expected value. In order to have an interesting problem we will assume that $E\left[v\left(p,k_p,0,z\right)\middle|0\right] > E[v(p,k_s,0,z)|0]$ and $E\left[v\left(p,k_p,1,z\right)\middle|1\right] < E[v(s,k_s,1,z)|1]$, where k_i is the optimal capital choice when crop i has been chosen. That is, perennial crops yield a higher expected utility whenever we face the transitory shocks, whereas seasonal crops are a better choice when facing the permanent shocks.

Because of the single crossing property described earlier and the supermodularity of the production function,[7] the choice of crops is monotone on the beliefs. In particular there will be a threshold belief $\hat{q}$ such that if beliefs are lower than $\hat{q}$ is optimal to choose the perennial crops. Analogously, if beliefs are higher than $\hat{q}$ then is optimal to choose the seasonal crops. Moreover, since beliefs are updated according to the violent shock, a more negative shock can change the optimal decision of the farmer from perennial crops to seasonal shocks if the updated shock crosses the threshold $\hat{q}$.

The interest of our work is also to understand how farmers change investment in the presence of violent shocks and uncertainty. Therefore we are interested on computing the derivative of k' with respect to the shock z and the belief q. First note that the problem is concave in k' and its first order condition is given by:

$$u'(c) = \beta\left[q'\int \frac{\partial v(i',k',q',z')}{\partial k}\,dG(z') + (1-q')\int \frac{\partial v(i',k',q',z')}{\partial k'}\,dH(z')\right]$$

where $\frac{\partial v(i',k',q',z')}{\partial k'} = u'(c')z'f_{i'}'(k')$

The left hand side of the equation is the opportunity cost of investing more in terms of current consumption. The right hand side of the equation represents the discounted future marginal benefits of investment, an increase in future consumption via an increase in the expected future production, weighted by the posterior belief. Note that investment will be higher when the farmer chooses the perennial crops since its marginal return is higher.

The comparative static with respect beliefs is given by:

[7] When functions are differentiable, supermodularity is equivalent to having a positive cross derivative.

$$\frac{\partial k'}{\partial q} = -\frac{\beta \frac{\partial q'}{\partial q} \Delta dv}{u''(c) + \beta E\left[\frac{\partial^2 v(i', k', q', z')}{\partial k'^2}\middle| q'\right]}$$

The term $\Delta dv = \int \frac{\partial v(i', k', q', z')}{\partial k'} dG(z') - \int \frac{\partial v(i', k', p', z')}{\partial k'} dH(z')$ denotes the difference on the expected marginal benefit of investment given the type of shock. Its sign will depend on how such marginal benefit depends on z. To find this we compute the cross partial derivative of the value function which is given by:

$$\frac{\partial^2 v(i', k', q', z')}{d\partial k' \partial z} = u'(c') f'_{i'}(k') \left[\frac{u''(c')}{u'(c')} z' f_{i'}(k') + 1\right]$$

If the farmer has a relative risk aversion greater than or equal to 1, a more negative shock implies a higher marginal benefit of investment.[8] This in turn implies that the expected marginal benefit is higher when facing a more permanent shock since $H(z')$ first order stochastically dominates $G(z')$, therefore Δdv is positive. Since the numerator of $\frac{\partial k'}{\partial q}$ is negative given the concavity of the problem, the result suggests that farmers invest more when they believe they are facing permanent shocks. The intuition for this result is that when the farmer expects negative shocks to be permanent and she is sufficiently risk averse, she values more insurance and the only instrument available is investment. However, such strategy lowers current consumption and thus the overall utility of the farmer.

We can also obtain the comparative static with respect to the violent shock:

$$\frac{\partial k'}{\partial z} = -\frac{-u''(c) f(k) + \beta \frac{\partial q'}{\partial z} \Delta dv}{u''(c) + \beta E\left[\frac{\partial^2 v(i', k', q', z')}{\partial k'^2}\middle| q'\right]}$$

The partial derivative $\frac{\partial q'}{\partial z} = \frac{q(1-q)\left(g'(z)h(z) - g(z)h'(z)\right)}{[g(z)q + h(z)(1-q)]^2} < 0$ denotes the change in beliefs after a shock. It is negative by the log supermodularity of the distributions, which is implied

[8] Having a constant relative risk aversion implies a positive third derivative, which is a necessary condition to have precautionary savings (Leland, 1968).

by the likelihood ratio ordering. Note also that this change in beliefs is close to zero when there is little uncertainty; that is when the farmer is almost sure that shocks are permanent (q is close to 1), or transitory (q is close to 0).

The numerator of $\frac{\partial k'}{\partial z}$ is negative and is also increasing in q' since the second derivative of the value function is decreasing in z. On the other hand, the denominator is positive whenever there is little uncertainty. This implies that a more negative shock reduces investment and that this reduction is larger under permanent shocks than under transitory ones.

However, when there is uncertainty, the reaction of farmers after a shock is mitigated or it can even change its sign. The intuition behind this result is that a more negative shock suggests that it is permanent, which leads the farmer to increase investment as a self-insurance strategy as shown in $\frac{\partial k'}{\partial q}$. This effect vanishes when there is no uncertainty since the effect on the updated beliefs also vanishes.

In sum, the model has several predictions that we test empirically. First, it predicts that more pessimistic beliefs (biased towards the permanent distribution) lead the farmer to choose seasonal crops in spite of being less profitable. Since beliefs are associated to the history of shocks that the farmer has experienced, regions with a more intense conflict should switch from perennial crops to seasonal crops. However, beliefs could also be associated to the presence of non-state armed actors in the region. Therefore, the greater the number of years the non-state armed actor has been in the region, beliefs should be more pessimistic and we should expect a higher proportion of people choosing seasonal crops.

Second, if farmers are sufficiently risk averse, more pessimistic beliefs induce them to invest more (although in a less profitable activity as we just mentioned) as a self-insurance strategy. Thus we should observe a greater investment the more years of presence of the non-state armed actor. On the other hand, a violent shock has two opposite impacts: it decreases investment since it decreases the available production, but it tends to increase investment at the same time since beliefs are now more pessimistic.

4. Empirical strategy

The purpose of the empirical analysis is to test the hypotheses put forth in the theoretical model. We measure shocks using violent shocks, while we use the number of years non-state armed actors have been present in the community as a proxy for beliefs on whether violent shocks are transitory or permanent. As non-state armed actors stay longer in the community, households believe with higher probability that non-state armed actors will become hegemonic in their region and thus expect shocks to be permanent. First, we test whether households that face a violent shock invest more in seasonal crops in contrast to permanent crops. We also test whether investments in seasonal crops are higher as the years of presence of non-state armed actors increase. Second, we gauge whether violent shocks reduce investment and if households increase investment in less profitable activities to increase their self-insurance as the years of presence of non-state armed actors is longer. Both predictions imply that violent shocks and a prolonged presence of non-state armed actors would push farmers to less risky, yet less profitable activities. Thus, conflict may push households to a low-income trajectory.

4.1.The Data

We use four different sources of data. The first source of data is the Colombian Longitudinal Survey of Universidad de los Andes (ELCA for its Spanish acronym). We designed ELCA to understand the impact of internal conflict on household welfare, labor markets, and agricultural production, among others. The first wave of the survey was administered during the first semester of 2010 to 10.800 households, 6.000 households in urban areas and 4.800 in rural regions. The survey is representative of urban households from income stratum one to four, and four rural micro-regions (Middle Atlantic, Central East, Cundi-Boyacense, and Coffee regions). We selected the rural micro-regions and municipalities within them to maximize variation in conflict intensity. Two regions had a high intensity of conflict (Middle-Atlantic and Central East) and two a low intensity (Cundi-Boyacense and Coffee region). Within each municipality, rural districts were chosen randomly. In this paper, we use the rural sample as conflict in Colombia occurs mainly in rural areas. In the sample, there are 17 municipalities and 222 rural districts in total. We only use households that report complete information on land use, and investment, which are 3,760 households.

The survey collects standard information about employment, income, consumption, education, health, family formation and social capital. For rural households, we collect detailed information on land tenure and property rights, agricultural production, and asset ownership. In addition, we designed a special module about shock incidence, which elicits information on conflict shocks. The questions were carefully designed to protect households, and reduce apprehension to answer accurately these questions. All households were geo-coded.

We also designed a rural district questionnaire applied to leaders of the community. The purpose of this questionnaire is to gather information on social and public infrastructure, incidences of shocks, including conflict, and access to markets. The questionnaire elicits detailed information on the history of conflict in the community during the last 10 years such as presence of non-state armed actors, imposition of rules and governance structures, and victimization of the civil population.

Despite carefully designing the rural questionnaire to reduce underreporting of presence of non-state actors and violent shocks, some underreporting may persist and it might be systematic. Some rural districts have a strong presence of non-state armed actors and underreporting might be larger in these areas. Respondents may face fear or misapprehension to provide detailed information related to conflict. With the purpose of correcting this potential underreporting, we complemented the rural questionnaire with information from the National Government. In particular, we use information on presence of non-state armed actors at the rural district level during the last 10 years.

To complement the above information, and using the coordinates in which each household is located, we construct a set of geographic variables that includes height above sea level of the household, distance to the state capital, to the nearest main road, to the nearest marine coast, other roads and coca crops. All distances are Euclidean and were calculated using data from IGAC[9], the Integrated System of Illicit Crop Monitoring (SIMCI) and the National Roads Institute (INVIAS). In addition, weather conditions faced by households were obtained from the data collected by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) between 1980 and 2009. The IDEAM collects

[9] Government institution responsible for collecting geographic information.

information on daily rainfall through 1,365 monitoring stations in the country. As the stations are geo-referenced, first we calculated monthly rainfall for each station and then, using the Kriging[10] method values, we assigned the values of rain to each household. Municipal characteristics come from the Economic Development Research Centre (CEDE) at Universidad de los Andes which covers the period from 1990 until 2010.

4.2. Estimation strategy

In order to understand the effect of conflict on agricultural decisions, we estimate the impact of violent shocks and years of presence of non-state armed actors on agricultural outcomes. We use two sets of agricultural outcomes: (i) the percentage of land dedicated to perennial crops, seasonal crops, pasture, or idle land; and (ii) whether the household did any investment in the land plot during the last three years, or invested in permanent structures, fruit trees or commercial trees during the last three years.

First, we estimate a naïve approach by assuming that conflict is exogenous. We use the following reduced form for household *i* located in rural district *j* and state *k*

$$y_{ijk} = \propto_0 + \alpha_k + X_{ijk}\beta + W_{jk}\gamma + \sum_{m=1}^{3} \theta_m P_{mjk} + \sum_{n=1}^{5} \lambda_n S_{njk} + \varepsilon_{ijk}$$

where y_{ijk} are outcomes related to agricultural decisions, X_{ijk} is a vector of household controls, W_{jk} is a vector of rural district controls, α_k are fixed effects at the state level, and ε_{ijkl} is a random term.

We capture conflict dynamics with the term $\sum_{m=1}^{3} \theta_m P_{mjkl} + \sum_{n=1}^{5} \lambda_n S_{njkl}$. The variable P_{mjkl} is a dummy equal to one if non-state actors have been present in rural district *jk*: (i) between one and three years; (ii) between four and six years; or (iii) between seven and nine years. These set of dummies capture how household adjust decisions to presence of non-state armed actors, after controlling for violent shocks, and θ_m are the parameters of

[10] Kriging is a spatial interpolation method that estimates surfaces from sampled point values. The estimated values are weighted averages of the observed values within a neighborhood of sampled points. We can be confident about the accuracy of our estimations because we have a large sample of points uniformly distributed over the surface of the country. Given the characteristics of our data we choose ordinary kriging for our rainfall interpolation.

interest. S_{njkl} is a dummy variable equal to one if rural district *jk* face *n* types of violent shocks (*n*=1,2,…,5). These set of dummies capture the direct impact of conflict through destruction, devastation, and market impacts. The parameters λ_n are traditionally estimated in other studies.

Although the household questionnaire collects information on covariate and idiosyncratic violent shocks, we believe that underreporting is high and we prefer to use the information collected on the rural district questionnaire for covariate shocks. Violent shocks reported in the rural district questionnaire are murder, cattle theft, land seizure, threats by non-state armed actors, and kidnappings.

By using dummy variables for years of presence and type of shocks, we are capturing the non-linear effects of both variables. At initial periods, households may react abruptly to presence of non-state actors. Once non-state actors stay for a longer period, households may habituate to their presence, and reactions are less abrupt or may converge to a low-income equilibrium, but with low risk of being victimized. We expect that the effect of presence of non-state armed actors is higher during the first years of presence and declines once households learn to live amidst conflict. On the other hand, an increasing number of types of shocks signal an intensification of the conflict. Thus, we expect the effect to be larger as the number of type of shocks increases.

Presence of non-state armed actors and violent shocks are not random. Non-state armed actors intend to control regions that serve their war objectives, such as extracting economic rents or illegally seizing valuable assets, or with lower costs to establish presence, such as difficult geographic conditions or alienation of the civil population against the state. In addition, aggressions against the civil population are deliberate and not a by-product of conflict. Non-state actors attack households with better-economic conditions to seize assets, or leaders of the community to weaken support to the opponent (Azam and Hoeffler 2002; Engel and Ibáñez 2007). If we do not account correct for endogeneity, our parameter estimates of θ_m and λ_n are biased.

To overcome this problem, we create pairs of contiguous rural districts with and without presence of non-state armed actors. By comparing contiguous districts, we control for

unobservables that vary smoothly across districts and are potential sources of bias. Geographic conditions, land productivity, and market shocks affect agricultural decisions and are also correlated with presence of non-state armed actors. These conditions are similar across rural district borders and within-neighbors identification control for these unobservables. Acemoglu et al (2012), Naidu (2012) and Dube et al (2010) use a similar spatial discontinuity strategy. In addition, we include a rich set of geographic, household, land plot, rural district and municipality controls that may also determine presence of non-state armed actors or incidence of violent shocks.

We estimate the following model for household *i* located in rural district *j* in pair *p* and

$$y_{ijp} = \propto_0 + \gamma_p + X_{ijp}\beta + W_{jp}\gamma + \sum_{m=1}^{3} \theta_m P_{mjp} + \sum_{n=1}^{5} \lambda_n S_{njp} + \varepsilon_{ijp}$$

Where γ_p denotes a rural district pair fixed effect.

We include household controls to account for preferences, and the life cycle such as gender and age of the household head. To control for wealth and potential targeting from non-state armed actors, we use years of education, and a wealth index constructed using principal components of household assets. We include variables for family composition (household size, number of members less 14 years of age, between 14-60 years old, and more than 60 years of age). Lastly, we have a dummy variable equal to one if the household is a beneficiary of *Familias en Acción*, a conditional cash transfer program.

We have a vector of land plot characteristic to control for variables that influence agricultural productivity. These variables also account for the value of land, thereby signaling the likelihood of being a victim of non-state armed actors. The controls include a dummy variable equal to one if the land plot has access to water sources, a dummy variable indicating whether the household has a formal legal title over the land plot, the rental value of the land[11], and the size of the land plot. Since the data is geo-coded, we control for a rich set of geographic characteristics at the plot level: the altitude above the sea level, distance

[11] Based on Colombian tax code and the appraisal values by municipality from IGAC, we calculate the rent for each household. The Colombian tax code states that the commercial value of a property must be maximum two times its appraisal, and that the rent should be maximum 1% of the commercial value. We calculate the rent for each household according to farm size.

in kilometers from the land plot to the state capital, primary roads, other roads, nearest seashore, and the nearest illicit crop cultivation. In order to capture other economic shocks that might be correlated to violent shocks, we include three variables that account for climate shocks: number of months during the previous years in which rain was one standard deviation below the historic mean, number of months during the previous years in which rain was one standard deviation above the historic mean, and the rainfall historic mean (Miguel, Satyanath et al. 2004).

We construct two additional geographical controls at the rural district level that influence agricultural productivity and the attractiveness of the rural district for non-state armed actors. The controls are distance in kilometers to the nearest river, and distance to the nearest water routes (sea or river).

In order to control for potential general equilibrium effects caused by conflict, we control for a price index of agricultural goods produced in the rural district and a dummy variable indicating whether the rural districts faces problems selling the agricultural goods[12]. We estimate the regressions with and without these variables to check for robustness as these variables are endogeneous.

Given that conflict in Colombia has a long history and intensified during the last two decades, we include the average municipal homicide rates for the period ranging from 1993 and 2000, and the average municipal homicide rates for the period ranging from 2000 and 2008. These variable controls for the historic effect of conflict.

4.3.Descriptive statistics

Presence of non-state armed actors, years of presence and incidence of violent shocks have a large variation across and within regions. Table 1 presents the distribution of years of presence for rural districts. A little more than 50 percent did not have presence of non-state armed actors between 2001 and 2010. The average years of presence of non-state armed

[12] We use the price per kilogram for each product by State for the period ranging from for 2006 and 2010, and calculate the average price for each community. Based on ELCA, we calculate the average production in kilograms by rural district. This data is used to compute the Paasche Index

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actors are 1,29, but the variance is large across rural districts as the standard deviation is 2.01. Rural districts with presence are concentrated between one and four years (37,9%). However, seven percent report a presence of five or more years.

[Table 1 goes about here]

Presence of non-state armed actors and incidence of violent shocks do not necessarily overlap. Table 2 reports incidence of covariate shocks by regions and by type of shocks. We divide incidence for rural districts with and without at least one year of presence of non-state armed actors. The overall incidence of shocks at the rural district and household level is 37.3 and 38.03 percent, respectively. For the whole sample, the percentage of rural districts affected by at least one shock does not differ for those with and without armed group presence. Nonetheless, when we compare these figures by the percentage of households affected, this percentage is much lower for districts with armed group presence (15.5%) than without (22.6%). This difference is particularly for the Middle-Atlantic and the Coffee Region, while in the Central Eastern region the overall incidence of shocks is higher for districts with armed group presence. Map 1 depicts overlapping between incidence of conflict shocks and presence of non-state armed actors for one of the four regions. The map clearly shows that violent shocks and presence of non-state armed actors do not necessarily coincide. Violent shocks occur frequently in rural district in which non-state armed actors are not present, and in many rural districts with presence of non-state armed actors the incidence of violent shocks is non-existent. Near 19.4 percent of rural districts with no presence of armed groups face a violent shock, while this figure is 16.5 percent for rural districts with presence.

Two reasons may explain this lower incidence. As discussed by Kalyvas (2006), violence against the civil population might be lower in regions with strong control from an hegemonic non-state armed actors. Another potential explanation is that the likelihood of underreporting incidence of violence is larger in regions with a stronger presence of non-state armed actors. Although we are able to correct for measurement error in years of presence, we do not have alternative sources of information for correcting incidence of covariate shocks. However, in the estimation we control for past history of homicide rates in the municipality, which is potentially correlated with incidence today.

When we divide incidence by type of shock, we find some interesting patterns. First, frequency of homicides is lower in rural districts with presence of non-state armed actors for the Middle-Atlantic and the Coffee regions. Second, cattle theft and homicides drive the higher incidence of shocks in districts with presence of armed groups of the Central Eastern region. Cattle theft and homicides might be the result of generalized crime, which is high in Colombia, and not necessarily the presence of armed groups. Third, threats from armed groups are higher in three of the four regions in rural districts with presence of armed groups. In these regions, non-state armed actors may exert a strong control, leading to higher threats, but lower incidence of other violent shocks. These patterns provide additional supports to Kalyvas (2006) hypothesis.

[Table 2 goes about here]

Table 3 presents descriptive statistics for all the outcome variables. We divide the results for rural districts without and with at least one year of presence from non-state armed actors, and with and without incidence of covariate conflict-induced shocks. Land is mostly dedicated to perennial (19.4%) and seasonal crops (15.4%), yet 6.2 percent of land is idle. In regions with a least one year of presence, households dedicate more percentage of land to perennial crops, pasture and idle land. By requiring less attention from farmers, both productive activities might be better suited for regions with armed conflict. In addition, cattle provide daily cash and can be easily sold if households are forced to migrate. Overall investment during the three years before the survey is low: only 14.1 percent of households invested. Overall investment is similar for regions with and without armed group presence. Households living in regions with presence of non-state armed actors invest more in fruit trees, and those located in regions without presence invest more in other commercial trees.

Agricultural outcomes for households living in rural districts with covariate violent shocks are also different. These households dedicate less land to perennial crops, and more land to pasture and idle use. In addition, these households invest more overall and in permanent structures and other commercial threes. Higher investment of these households may signal targeting of non-state armed actors to wealthier households in the community.

[Table 3 goes about here]

Tables 5 and 6 report descriptive statistics for control variables for the overall sample, and divided by presence of non-state armed actors, and incidence of conflict shocks. Rural districts with at least one year of presence of non-state armed actors are systematically different from those without presence. Nonetheless, the difference is driven mostly by geographic characteristics and not by household characteristics. The former have a younger population, with smaller households, less wealthy and with lower access to water sources for agricultural production. For other household characteristics, the differences are not statistically significant. In rural districts with presence of non-state armed actors, weather variability is higher (more months of dry and rainy season), but with a drier weather historically. These rural districts are located in higher altitude, are more isolated, which facilitate the actions of non-state armed actors, and the prices of agricultural goods are higher. Lastly, the history of violence in these municipalities is stronger as average municipal rates are higher for both periods.

Again, differences in household characteristics between rural districts with and without conflict shocks are small. Compared to rural district without shocks, districts with shocks have more educated household heads, a younger population, and less access to the conditional cash transfer program. Some interesting differences emerge on the characteristics of land plots that may signal targeting of household with more valuable land, yet with a weaker regime of property rights over land. In rural districts with conflict shocks, informality of land property rights is higher, land is more valuable (measured by the rental value of land) and have more access to water sources for agricultural production. These districts are located in a higher altitude, are isolated and far away from the state's capital, and sea- shores and the prices of agricultural goods are lower, but these households are closer to regions with illicit crop production. In addition, these districts faced more climatic shocks in the year previous to the survey. Homicide rates in the municipalities in which these districts are located are lower in both periods for those that faced at least one shock compared to those without shocks.

[Table 5 goes about here]

[Table 6 goes about here]

The descriptive statistics show small differences on household characteristics in districts with and without armed group presence. Nonetheless, geographic characteristics are systematically different according to presence of non-state armed actors, and conflict shocks. Our estimation strategy solves this endogeneity by creating contiguous pairs of communities. Table 7 identifies if our estimation strategy is effective to reduce the household and geographical differences for rural districts with and without presence of non-state armed actors. We first regress each control on state fixed effect and a dummy variable equal to one if the household live in a rural district with armed group presence. Then, we estimate the same regression but instead of the state fixed effect we include the fixed effects for the contiguous pairs. The coefficient estimate for the dummy variable on armed group shows that the difference between household characteristics are even lower after we control for the fixed effect on the contiguous pairs. Nonetheless, differences in characteristics related to the value of the land plot are stronger, showing non-state armed actors target households with more valuable land. To test this may pose a threat to our identification strategy, we estimate the regressions with and without these controls (whether the land plot has a legal title and whether the land plot has access to water sources) and find similar results. The differences on geographic characteristics are also smaller. Two of the coefficient estimates are no longer statistically significant and the magnitude for almost all the others decreases considerably. It is worth mentioning that we control for these geographic characteristics on all the estimations.

[Table 7 goes about here]

4.4.Estimation results

This paper examines the impact of conflict on agricultural production of small farmers. We explore two channels through which conflict affects agricultural production: presence of non-state armed actors, and incidence of violent shocks. We concentrate on land use, and investments. For each outcome, we report three columns. The first column reports the results for the naïve approach with state fixed effects, the second column the results when we control for the fixed effects of the contiguous pairs, and the third column controls for potential general equilibrium effects (daily agricultural wage and a price index for

agricultural goods produced in the rural district). The coefficient estimates for the controls are robust to including the general equilibrium effects.

Table 8 reports the estimation results for the percentage of land dedicated to perennial crops, seasonal crops, pastures and idle land. Similarly to findings in other papers (Bozzoli and Brück 2009; Verpoorten 2009), we find that households react to conflict shocks by changing productive decisions. As a result of the shocks, households dedicate less land to perennial crops and pasture, more land to seasonal crops and a higher percentage of the land is left idle. Adjustments in land use are particularly strong in rural districts with a high intensity of violent shocks, measured as those with two or three type of shocks. These changes are highly non-linear such that the impact of two types of shocks is much lower than the impact of three types of shocks. For example, the impact of two types of shocks on idle land is -0.06, while this figure for three types of shocks is -0.368. After controlling for general equilibrium effects, the impact of shocks on land dedicated to perennial crops weakens, while for seasonal crops and pastures the coefficient estimates are indeed similar. Interestingly, the impact for idle land becomes stronger, in particular for one type of shocks that was not statistically significant. Changes in relative prices, such as the price of the agricultural produce, seem to signal a structural adjustment pushing households to reduce agricultural production.

Presence of non-state armed actors exerts a different effect than conflict shocks. The results show that households presumably habituate to living amidst conflict once the presence of non-state armed actors is more prolonged. During the initial period of presence, from one to three years of presence, households adjust strongly their productive decisions. The percentage of land allocated to perennial crops, or pasture, while production in seasonal crops is similar. Once households perceive the presence of non-state armed actors as permanent, from seven years onwards, the percentage of land allocated to pastures, and idle land increase. Thus, as predicted by the model, once the presence of non-state armed actors is deemed as permanent, production concentrates on less profitable activities. Pasture, which is used to feeding livestock, is also an alternative. Livestock provide daily cash and can be easily sold if households need to leave when the conflict intensifies. However, a prolonged presence of non-state armed actors pushes households to exploit a lower

percentage of their land. When we control for general equilibrium effects, the presence of non-state armed between four and six years increases the percentage of land allocated to perennial crops. In addition, the impact of presence becomes stronger for pastures and idle land.

[Table 8 goes about here]

Table 9 reports the results for investment. Incidence of conflict shocks has a strong impact on investment decisions. Overall investment decreases as a consequence of the conflict shock: the probability of investment for two and three types of shocks is 23.3 and 36.6 percentage points lower, respectively. Decreases in overall investment are mostly related to a lower investment in commercial trees. These results hold after controlling for general equilibrium effects. We find a counterintuitive result for permanent structures: two and three types of shocks increase investment in permanent structures. Once we control for general equilibrium effects, the statistical significance for the impact of three types of shocks disappears. Although we control for several variables that capture wealth and regional characteristics to account for potential targeting, we might not be able to fully control for this.

Years of presence from non-state armed actors have a non-linear effect. Households seem to adjust their behavior gradually. Initial beliefs may perceive the presence of non-state armed actors as transitory, which prompts households to sharply reduce investments. As presence is more prolonged, the presence might be perceived as permanent and households learn to live amidst conflict and invest more. We indeed find these results for overall investment and for investments in permanent structures, fruit trees and other commercial trees. During the first years of presence (one to three years), overall investment decreases by 26.9 percent. The following periods overall investment increases gradually such that between four and six years it increases by 26 percent and from seven onwards by 83.6 percent. The results hold after controlling for general equilibrium, effect. We find this positive impact for overall investment, and commercial trees. Indeed, farmers apparently learn to live amidst conflict and update the investments they have postponed for several years.

[Table 9 goes about here]

Our results show that the impact of conflict shocks and presence of non-state armed actors on household decisions differ. The resilience of households and their ability to navigate conflict becomes evident when we explore the impact of the years of presence. Examining only the impact of conflict shocks provide an incomplete picture in which violence has a negative effect with little capacity of households to minimize it. The findings also show a high non-linearity of both effects. As conflict shocks increase, the negative impact becomes stronger. On the other hand, households react with sharp reductions in agricultural production and investment at the initial stages of presence of non-state armed actors, and gradually learn to live among armed groups.

4.5. Robustness check

A potential confound to the identification strategy are the spillovers across boundaries of the rural districts. These spillovers may arise because presence of non-state armed actors may have an impact beyond the borders of the rural district, and households may migrate to neighboring districts to avoid the impacts of conflict. We perform three robustness checks. First, similarly to Naidu (2012), we create alternative pairs such that we compare results for the immediate neighbor with results using the immediate neighbor of the original pair. We drop from the estimation the original pairs, reducing our sample to 2.496. Second, we use propensity scores to match rural districts with presence of non-state armed actors to five rural districts without presence with the closest PSM. Third, we drop migrants from the estimations in order to estimate the effect only for those households that were born and have lived in the rural district in which they were interviewed.

We present results for the three robustness checks on Table 10. The first column reports the results for the immediate neighbor of the contiguous region (INCR), the second for the propensity score matching (PSM) and the third for the sample on permanent residents. Our results are robust to the different specification, yet some coefficient estimates loses significance as for all cases we have less observations. We expect that the coefficient estimates for the INCR and the PSM are weaker in terms of magnitude and significance. In both cases, our ability to control for unobservables is lower, in particular for the PSM. For

the case of the INCR, the sample size is smaller, which may reduce the precision of the coefficient estimates. This is indeed the case. Many coefficient estimates are no longer significant, and their magnitude is lower. However, the results for the coefficient estimates coincide for more than half of the cases.

The results for the sample of permanent residents show a stronger impact. Permanent residents have stronger links with their community and are less likely to migrate. Thus, we expect their reactions to shocks and presence of non-state armed actors to be stronger. The coefficient estimates for permanent residents have in most cases the same signs as the original results, yet their magnitude is larger and some additional ones become statistically significant.

5. Conclusions

This paper studies how conflict induces changes on households' agricultural decisions. We explore whether households respond differently to conflict shocks and uncertainty, risk and the governance structures imposed by non-state armed actors. Households may react strongly to violent shocks and presence of non-state armed actors if conflict is recent. However, households may learn to live amidst conflict, and adapt their behavior to prevent aggressions from non-state armed actors, and mitigate the economic consequences of violence.

We first propose a model that highlights the distortions faced by a small farmer living in autarky who is hit by violent shocks, but is uncertain of the nature of the shocks. Shocks may arise when either the government or the non-state armed actor are hegemonic in the region; in the latter case, shocks tend to be worse (in the likelihood ratio sense). Therefore a more violent shock leads the farmer to update beliefs and think with a higher probability that the non-state armed actor will dominate his region. We concentrate on the impact that violent shocks and uncertainty have on land use and investment.

It is shown that more pessimistic beliefs and more violent shocks lead the agent to change perennial for transitory crops, which are less risky but less profitable. On the other hand, if the farmer is sufficiently risk averse, then the more pessimistic beliefs the farmer has, the more he invests to self-insure. This generates a non-linear effect on investment once a

violent shock arises. On one hand, a violent shock decreases investment since production decreases; but on the other hand, he updates his belief and increases investment for self-insurance motives. The more uncertain is the farmer, the stronger is the latter effect.

We apply a household survey representative of four Colombian micro-regions to test these predictions. Colombia has faced a civil war for more than half a century; thus, it is the ideal context to investigate how households adjust their decisions in conflict-ridden regions. Because presence of non-state armed actors is not random, our empirical strategy creates contiguous pair of rural districts with and without presence of non-state armed actors. We include fixed effects for each contiguous pair, which controls for unobservables that are potentially correlated with armed group presence and may bias our coefficient estimates. We also include a rich set of controls at the household, land plot, rural district, and municipality level.

The results of the paper show that households' responses to violent shocks and presence of non-state armed actors differ. High intensity of shocks induce changes in land use such that households in rural districts with a larger number of violent shocks use less land on perennial crops and pasture, and more on seasonal crops and idle. In addition, the conflict shock causes a decrease in overall investment. The impact of shocks is highly non-linear such that the magnitude increases significantly as the incidence becomes stronger.

Presence of non-state armed actors prompts different responses from households. We find that, similarly to Kalyvas (2006), presence of armed groups does not necessarily coincide with violent aggressions against the civil population. In fact, incidence of violent shocks is lower in rural districts with presence of non-state armed actors. This implies households may adjust behavior to prevent future aggressions, become less visible to armed groups, or to reduce other costs of conflict. Responses of households to the presence of non-state armed actors signal that they learn to live amidst conflict. When presence of non-state armed actors is recent, households cut-back strongly land use on perennial crops, pasture and idle as well as investments As presence of non-state armed actors is more prolonged, farmer increase land use on perennial crops and pasture, yet more land is left idle. Also, investments rebound after longer years of presence. These results show households habituate to conflict, yet in a lower equilibrium.

Traditional post-conflict policies concentrate on reconstruction efforts, which are necessary to increase production in a short period of time as this paper shows. However, policies should also create favorable conditions to reduce uncertainty. An initial step would be to rapidly improve the rule of law. In addition, policies that go beyond individual beneficiaries and target the community could improve trust among households, reducing the perception of uncertainty. Reducing uncertainty, paired with access to formal credits, induce households to expand investment and avoid sub-optimal decisions.

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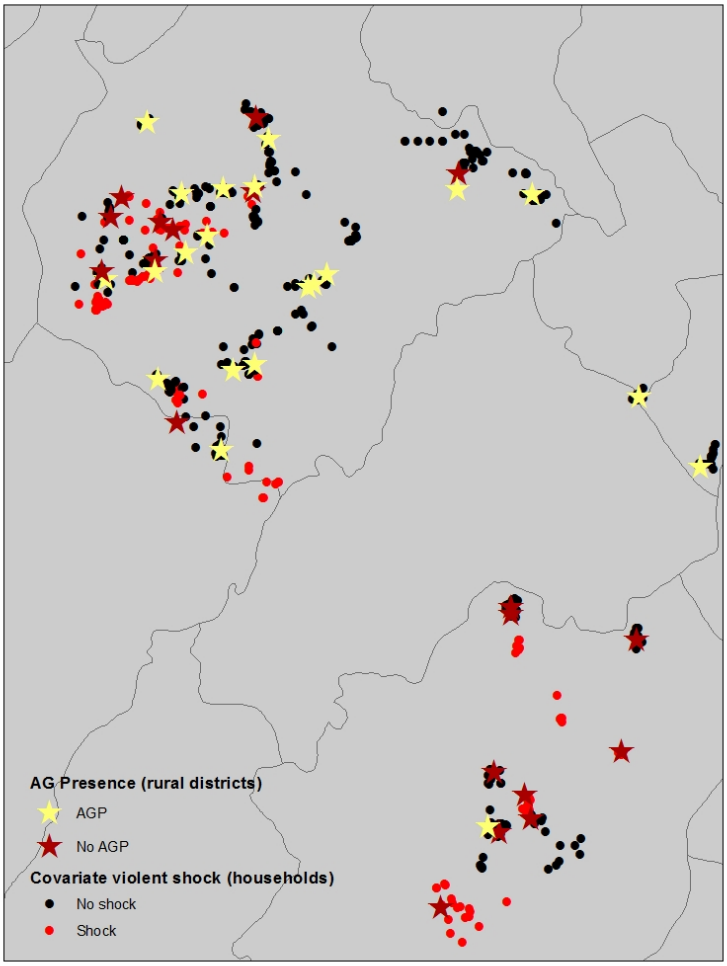
Map 1. Presence of non-state armed actors and incidence of conflict-induced shocks



Source: Authors' calculations based on ELCA (Wave I) and National Government

Table 1. Years of presence of non-state armed actors (% rural districts)

Years of presence	Rural districts	Percentage
0	171	76.3%
1	23	10.3%
2	3	1.3%
3	2	0.9%
4	19	8.5%
5	3	1.3%
6	3	1.3%
Mean (Standard deviation)	0,64 (1,4)	

Source: Authors' calculations based on ELCA (Wave I) and National Government

Table 2. Incidence of conflict-induced shocks by regions: with and without presence of non-state armed actors (% rural districts)

Micro-Region	Rural district	
	No presence	Presence
Middle-Atlantic	21%	5%
Cattle Theft	6%	0%
Homicides	6%	0%
Land seizure	0%	0%
Kidnaps	0%	0%
Threats from armed groups	8%	14%
Cundi-Boyacense	34%	52%
Cattle Theft	59%	69%
Homicides	13%	19%
Land seizure	0%	0%
Kidnaps	0%	0%
Threats from armed groups	0%	0%
Coffee region	29%	14%
Cattle Theft	17%	17%
Homicides	13%	8%
Land seizure	4%	0%
Kidnaps	0%	0%
Threats from armed groups	4%	0%
Central East	16%	29%
Cattle Theft	5%	33%
Homicides	15%	0%
Land seizure	0%	0%
Kidnaps	7%	0%
Threats from armed groups	5%	0%

Source: Authors' calculations based on ELCA (Wave I) and National Government

Table 3. Descriptive statistics: outcome variables

	=1 at least one year of presence			=1 at least one conflict-induced shock		
	No	**Yes**		**No**	**Yes**	
Annual agricultural income/hectares	2.44	0.08	-	3.17	0.11	-
	(87.2)	(0.50)		(100.0)	(0.47)	
Costs/hectares	1.58	0.09	-	2.05	0.09	-
	(56.99)	(0.82)		(65.42)	(0.70)	
% of land used in perennial crops	23.4%	27.4%	**	27.4%	19.2%	***
	(0.34)	(0.37)		(0.36)	(0.31)	
% of land used in seasonal crops	16.7%	15.3%	-	15.3%	18.2%	***
	(0.29)	(0.27)		(0.29)	(0.29)	
% of land used in pasture	6.6%	10.0%	***	6.1%	9.2%	***
	(0.18)	(0.21)		(0.17)	(0.20)	
=1 if invested in land plot since 2007	19.1%	23.2%	**	19.3%	20.8%	-
	(0.39)	(0.42)		(0.40)	(0.41)	
Observations	1,439	362		1,092	709	
=1 if hh had a credit with banks on survey day	62.6%	68.7%	**	58.9%	70.8%	***
	(0.48)	(0.46)		(0.49)	(0.45)	
=1 if hh had credit with family and friends on survey day	29.2%	30.0%	-	29.7%	29.0%	-
	(0.45)	(0.46)		(0.46)	(0.45)	
Observations	933	300		698	535	

Source: Authors' calculations based on ELCA (Wave I) and National Government * p<0.10, ** p<0.05, ***p<0.01

Table 4a. Descriptive statistics: control variables (household characteristics)

	=1 at least one year of presence			=1 at least one conflict-induced shock		
	No	**Yes**		**No**	**Yes**	
Number of members	4.71	4.62	-	4.64	4.75	-
	(2.02)	(1.94)		(1.99)	(2.00)	
=1 if household head is man	85.4%	85.3%	-	84.7%	86.4%	-
	(0.35)	(0.35)		(0.36)	(0.34)	
Household head's age	46.6	45.1	**	46.2	46.3	-
	(12.6)	(11.8)		(12.5)	(12.4)	
Household's head years of education	4.88	4.51	**	4.87	4.68	-
	(3.58)	(3.38)		(3.47)	(3.62)	
Members between 14-60 years old	2.93	2.87	-	2.94	2.89	-
	(1.41)	(1.37)		(1.40)	(1.40)	
Members less than 14 years	1.36	1.35	-	1.29	1.43	**
	(1.34)	(1.30)		(1.31)	(1.36)	
Members more than 60 years	0.42	0.40	-	0.41	0.42	-
	(0.68)	(0.66)		(0.67)	(0.70)	
=1 if is beneficiary of Familias en Acción	37.2%	40.0%	-	38.0%	37.8%	-
	(0.48)	(0.49)		(0.49)	(0.49)	
Wealth index	0.05	-0.10	-	0.09	-0.09	*
	(2.27)	(2.03)		(2.36)	(1.99)	
Observations	933	300		698	535	

Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.

* p<0.10, ** p<0.05, ***p<0.01

Table 4b. Descriptive statistics: control variables (land plot and geographic characteristics)

	=1 at least one year of presence			=1 at least one conflict-induced shock		
	No	**Yes**		**No**	**Yes**	
Land plot size (hectares)	1.56	2.82	-	3.5	3.2	-
	(4.78)	(4.88)		(5.03)	(4.48)	
=1 if land tenure is formal	25.9%	26.0%	-	28.7%	22.4%	***
	(0.44)	(0.44)		(0.45)	(0.42)	
Rental value of land	564,870	536,983	-	526,645	599,104	-
	(1'179,092)	(741,126)		(1'113,876)	(1'054,468)	
=1 if has access to water sources	65.1%	54.7%	***	61.2%	64.3%	-
	(0.48)	(0.50)		(0.49)	(0.48)	
=1 if fertility is high	1.5%	1.7%	-	1.6%	1.5%	-
	(0.12)	(0.13)		(0.12)	(0.12)	
=1 if fertility is from high to moderate	2.1%	0.0%	***	1.7%	1.5%	-
	(0.14)	(0.00)		(0.13)	(0.12)	
=1 if fertility is moderate	9.1%	6.3%	**	11.0%	5.0%	***
	(0.29)	(0.24)		(0.31)	(0.22)	
=1 if fertility is from moderate to high	20.6%	7.7%	***	24.6%	8.0%	***
	(0.40)	(0.27)		(0.43)	(0.27)	
=1 if fertility is from moderate to low	0.9%	1.3%	-	0.9%	1.1%	-
	(0.09)	(0.11)		(0.09)	(0.11)	
=1 if fertility is low	10.6%	18.7%	***	6.3%	20.7%	***
	(0.31)	(0.39)		(0.24)	(0.41)	
=1 if fertility is from low to moderate	22.0%	39.0%	***	23.4%	29.7%	***
	(0.41)	(0.49)		(0.42)	(0.46)	
=1 if fertility is very low	7.8%	6.7%	-	7.4%	7.7%	-
	(0.27)	(0.25)		(0.26)	(0.27)	
=1 if fertility is from very low to low	24.7%	18.0%	***	21.9%	24.5%	-
	(0.43)	(0.38)		(0.41)	(0.43)	
Months of drought	1.6	1.5	**	1.3	1.9	***
	(1.11)	(0.96)		(1.10)	(0.93)	
Months of wetness	0.69	0.80	**	0.97	0.39	***
	(0.88)	(0.93)		(0.95)	(0.69)	
Average historic rainfall	147.8	130.5	***	148.3	137.4	***
	(28.6)	(36.3)		(29.1)	(33.4)	
Height above sea level	1,466	1,705	***	1,197	1,951	***
	(1,020)	(1,050)		(958)	(970)	
Distance to the state's capital (km)	66.2	73.9	***	61.6	76.6	***
	(44.7)	(42.3)		(36.5)	(51.4)	
Distance to primary roads (km)	7.4	7.8	-	7.8	7.0	**
	(9.15)	(7.28)		(9.00)	(8.37)	
Distance to other roads (km)	3.8	3.2	***	3.5	3.9	**
	(2.37)	(2.29)		(2.4)	(2.3)	
Distance to the sea (km)	188.5	214.2	***	162.3	237.1	***
	(125.2)	(104.3)		(113.1)	(117.8)	
Distance to coca crops (km)	81.0	81.6	-	88.3	71.8	***
	(33.6)	(36.6)		(33.7)	(32.8)	
Observations	933	300		698	535	

Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.
* p<0.10, ** p<0.05, ***p<0.01

Table 5. Descriptive statistics: control variables (rural district and municipality characteristics)

	=1 at least one year of presence			=1 at least one conflict-induced shock		
	No	**Yes**		**No**	**Yes**	
Distance to nearest river (km)	13.1	11.2	***	14.5	10.1	***
	(11.8)	(10.5)		(12.4)	(9.7)	
Distance to sea and river routes (km)	84.1	79.2	***	75.6	92.5	***
	(20.0)	(35.9)		(23.4)	(23.5)	
Price index of the community	1.14	1.22	***	1.17	1.15	-
	(0.33)	(0.33)		(0.27)	(0.40)	
=1 if community has problems to get credit	41.8%	44.0%	-	41.8%	43.0%	-
	(0.49)	(0.50)		(0.49)	(0.50)	
Number of banks on municipality	1.8	1.5	***	1.96	1.44	***
	(0.03)	(0.06)		(0.88)	(0.95)	
Daily agricultural wage	11,788	12,760	***	11,725	12,414	***
	(2,974)	(1,871)		(3,157)	(2,126)	
Municipal homicide rate 1993-2000	61.1	62.3	-	65.8	55.7	***
	(45.4)	(44.4)		(51.6)	(34.2)	
Observations	933	300		698	535	

Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.

* p<0.10, ** p<0.05, ***p<0.01

Table 6. OLS estimation – yearly agricultural revenues per hectare

	(1)	(2)	(3)
Shock intensity	0.0727		
	[0.0803]		
Years of armed group presence	0.00810		
	[0.0544]		
Intensity 1		0.132	0.145
		[0.128]	[0.129]
Intensity 2		0.179	0.152
		[0.219]	[0.226]
Intensity 3		-0.498*	-0.579*
		[0.295]	[0.307]
One year of presence		0.248*	0.269*
		[0.135]	[0.138]
Two years of presence		0.260	0.218
		[0.191]	[0.192]
Three years of presence		0.263	0.304
		[0.689]	[0.673]
Four years of presence		-0.205	-0.242
		[0.364]	[0.357]
Five years of presence		0.298	0.365
		[0.365]	[0.354]
Six years of presence		-0.882*	-0.783
		[0.513]	[0.519]
Observations	1801	1801	1801
R-squared	0.161	0.165	0.166
Household and land plot characteristics	Yes	Yes	Yes
Rural district and municipality controls	Yes	Yes	Yes
General equilibrium variables	No	No	Yes
Fixed effects by department	Yes	Yes	Yes
Clustered by rural district	Yes	Yes	Yes

Robust standard errors in brackets. * p<0.10, ** p<0.05, ***p<0.01
Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.

Table 7. OLS estimation – yearly agricultural costs per hectare

	(1)	(2)	(3)
Shock intensity	0.112		
	[0.0878]		
Years of armed group presence	0.0909		
	[0.0706]		
Intensity 1		0.166	0.190
		[0.135]	[0.134]
Intensity 2		0.117	0.0472
		[0.254]	[0.256]
Intensity 3		0.373	0.225
		[0.280]	[0.317]
One year of presence		0.452***	0.494***
		[0.157]	[0.164]
Two years of presence		0.330	0.215
		[0.357]	[0.356]
Three years of presence		0.646	0.773
		[1.036]	[0.961]
Four years of presence		-0.0804	-0.163
		[0.380]	[0.383]
Five years of presence		0.433	0.625
		[0.518]	[0.484]
Six years of presence		-0.0600	0.188
		[0.459]	[0.473]
Observations	1801	1801	1801
R-squared	0.208	0.212	0.218
Household and land plot characteristics	Yes	Yes	Yes
Rural district and municipality controls	Yes	Yes	Yes
General equilibrium variables	No	No	Yes
Fixed effects by department	Yes	Yes	Yes
Clustered by rural district	Yes	Yes	Yes

Robust standard errors in brackets. * p<0.10, ** p<0.05, ***p<0.01
Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.

Table 8. OLS estimation – land allocation: perennial crops, seasonal crops, and pasture (Percentage of total land plot)

	Perennial Crops			Seasonal Crops			Pastures		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shock intensity	-0.0124			0.0195*			0.00518		
	[0.0159]			[0.0118]			[0.0120]		
Years of armed group presence	0.00465			0.00106			0.00298		
	[0.00943]			[0.00781]			[0.00541]		
Intensity 1		-0.0340	-0.0303		0.0163	0.0160		0.0178	0.0180
		[0.0210]	[0.0206]		[0.0185]	[0.0182]		[0.0123]	[0.0117]
Intensity 2		0.0390	0.0337		0.0232	0.0268		-0.0401***	-0.0428***
		[0.0354]	[0.0370]		[0.0250]	[0.0263]		[0.0150]	[0.0146]
Intensity 3		-0.192***	-0.216***		0.182***	0.181***		0.210***	0.214***
		[0.0471]	[0.0425]		[0.0366]	[0.0365]		[0.0222]	[0.0213]
One year of presence		0.0829**	0.0880***		-0.0112	-0.0105		0.00448	0.00167
		[0.0323]	[0.0330]		[0.0228]	[0.0234]		[0.0143]	[0.0144]
Two years of presence		-0.00527	-0.0119		0.0798	0.0838		-0.0227	-0.0216
		[0.0369]	[0.0392]		[0.0798]	[0.0799]		[0.0138]	[0.0131]
Three years of presence		0.100**	0.105**		0.00698	-0.00245		-0.0161	-0.00864
		[0.0503]	[0.0528]		[0.0283]	[0.0305]		[0.0113]	[0.0124]
Four years of presence		-0.0199	-0.0277		0.0568	0.0569		0.0697	0.0740
		[0.0632]	[0.0646]		[0.0598]	[0.0627]		[0.0479]	[0.0452]
Five years of presence		-0.00344	0.00541		-0.0335	-0.0424		-0.0149	-0.0136
		[0.0839]	[0.0905]		[0.0478]	[0.0485]		[0.0387]	[0.0398]
Six years of presence		-0.120	-0.101		-0.0832	-0.0927		0.0230	0.0256
		[0.0842]	[0.0817]		[0.0600]	[0.0638]		[0.0562]	[0.0562]
Observations	1801	1801	1801	1801	1801	1801	1801	1801	1801
R-squared	0.199	0.208	0.211	0.220	0.224	0.226	0.135	0.149	0.154
Household and land plot characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rural district and municipality controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
General equilibrium variables	No	No	Yes	No	No	Yes	No	No	Yes
Fixed effects by department	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered by rural district	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in brackets. * p<0.10, ** p<0.05, ***p<0.01

Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.

Table 9. Probit estimation – access to formal and informal credits, and investment decisions since 2007

	=1 if credit with banks			=1 if credit with family and friends			=1 if at least one investment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shock intensity	0.0462			-0.0229			-0.0428**		
	[0.0285]			[0.0247]			[0.0172]		
Years of armed group presence	0.00321			-0.0142			0.0163		
	[0.0159]			[0.0151]			[0.0195]		
Intensity 1		-0.0296	-0.0519		0.0300	0.0273		-0.0238	-0.0227
		[0.0368]	[0.0365]		[0.0340]	[0.0345]		[0.0263]	[0.0268]
Intensity 2		0.0819	0.0698		-0.0344	-0.0323		-0.116**	-0.123***
		[0.0502]	[0.0503]		[0.0412]	[0.0405]		[0.0448]	[0.0461]
Intensity 3		0.530***	0.565***		-0.367***	-0.339***		-0.209***	-0.215***
		[0.0822]	[0.0812]		[0.0909]	[0.0916]		[0.0456]	[0.0427]
One year of presence		-0.0976*	-0.107**		0.120**	0.124**		0.0112	0.0141
		[0.0500]	[0.0477]		[0.0524]	[0.0508]		[0.0330]	[0.0329]
Two years of presence		0.106	0.147		-0.0352	-0.0544		0.0603	0.0467
		[0.0806]	[0.0940]		[0.0973]	[0.0978]		[0.0504]	[0.0541]
Three years of presence		-0.0777	-0.0573		0.106	0.115		-0.110***	-0.0932***
		[0.111]	[0.117]		[0.165]	[0.144]		[0.0343]	[0.0322]
Four years of presence		0.0212	0.116		-0.227***	-0.253***		0.0972	0.0898
		[0.102]	[0.108]		[0.0856]	[0.0935]		[0.0864]	[0.0854]
Five years of presence		0.140	0.222**		-0.227***	-0.229***		0.340***	0.364***
		[0.0871]	[0.0864]		[0.0750]	[0.0873]		[0.0921]	[0.0972]
Six years of presence		-0.0921	0.0249		0.0281	0.0306		-0.127	-0.101
		[0.155]	[0.155]		[0.155]	[0.160]		[0.143]	[0.147]
Observations	1233	1233	1233	1233	1233	1233	1801	1801	1801
R-squared	0.210	0.222	0.231	0.086	0.101	0.105	0.130	0.138	0.141
Household and land plot characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rural district and municipality controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
General equilibrium variables	No	No	Yes	No	No	Yes	No	No	Yes
Fixed effects by department	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered by rural district	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in brackets. * p<0.10, ** p<0.05, ***p<0.01

Source: Authors' calculations based on ELCA (Wave I), National Government, IDEAM, IGAC and CEDE Municipal Panel.