Property rights and conflicts: theory and evidence from the Highland of Ethiopia

Preliminary and incomplete

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Abstract

This paper investigates the link between insecure property rights and local conflicts using household level data in Ethiopia. We offer two main contributions. *First*, we develop a simple theoretical framework of land conflict. *Second*, guided by our theoretical framework, we empirically assess the causal relationship between land tenure security and conflict using micro-level data. Our identification strategy relies on both the exogenous variation in climatic factors and a natural experiment of a randomly assigned land certification program in Ethiopia. We find that having tenure security reduces the probability for a household to experience a conflict by 5%. We highlight that tenure security reduces conflict by diminishing the vulnerability of rural household to rainfall anomalies.

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1 Introduction

It is often purported that insecure property rights over land are an important factor behind social conflict and violence in the developing world. A typical illustration is the Kenyan case where, in the aftermath of the early 2008 post-election violence, the "Kenya National Dialogue and Reconciliation" process identified land reform as key to peace and reconciliation. Case studies linking ill-defined property rights and conflicts abound in the literature: the fact that many individuals may have claims to the same piece of land is alleged to exacerbate tensions and generate violence. The key issue in the literature lies in identifying the causal effect of changes in property rights on violence.

A growing body of literature studies the causal channel linking insecure property rights and economic outcome (e.g. Besley, 1995, Goldstein and Udry, 2008, Besley et al., 2012, Acemoglu et al., 2014). Little attention has been paid however to the link between tenure security and local conflict[1] despite the fact that smaller scale, localized conflicts can severely affect welfare and economic development. Furthermore, it is well documented that small scale violence can escalate into large-scale disputes, social unrest, and political movements under the right circumstances (Andre and Platteau, 1998).

This paper investigates the link between insecure property rights and local conflicts using household level data in Ethiopia. We offer two main contributions. *First*, we develop a simple theoretical framework of land conflict. The model makes a clear prediction: in dire times (i.e. when water is scarce), bargaining may breakdown and conflict over land arises if property rights are ill-defined. *Second*, guided by our theoretical framework, we empirically assess the *causal* relationship between tenure security and conflict using micro-level data in Ethiopia. Our identification strategy relies on the exogenous variation in cli-

[1]Notable exception is Jia (2013) who finds that the introduction of agricultural technology reduces the probability of weather-driven revolts in rural China.

matic factors, and on a natural experiment of a large and randomly assigned land certification program implemented by the World Bank in the Highlands of Ethiopia. We exploit both the random assignment of secure property rights via the land certification program and the exogenous variation in climatic factors to investigate whether the relationship between rainfall anomalies and land related conflicts is sensitive to strengthened tenure security over the land operated by rural households. We find that (i) farm-households with secure land tenure are less prone to conflicts and (ii) that this effect transit through less vulnerability to water scarcity.

Our theoretical framework is a simple bargaining model with private information. In particular we assume that agents bargain over a piece of land. One agent can rely on violence to seize the land, albeit at a (privately known) cost[2]. This cost reflects the strength of property rights in the region: the cost is substantive if the land is secure and low (with a high probability) if property rights are ill-defined. When agents face a common water shock, the temptation to rely on violence rises along with the marginal value of land. This setup gives rise to a simple Perfect Bayesian Equilibrium in which we observe a higher chance of conflict in dire times. Tenure security dampens substantially the effect of scarcity on conflict.

Our empirical analysis relies on a large panel dataset from farm-household surveys conducted in the Amhara region of Ethiopia in years 2005 and 2007. We use rainfall anomalies as climatic variables (Miguel et al, 2004; Couttenier and Soubeyran, 2014). An important advantage of this metrics is that it highlights the *variation* in weather compared to a long run trend (in our case 30 years). This approach captures the exceptionality of weather shocks, and thus, it allows to investigate whether farm-households with tenure security are more resilient to weather anomalies, and less likely to experience conflicts. We first show that

[2]This model is very close in spirit to the traditional model presented in Besley and Gathak, 2009, where property rights are modelled as an exogenous probability of being expropriated.

having tenure security reduces the occurrence of conflict by 5% for the average household. We then present robust evidence that rainfall anomalies affect land use conflicts: our baseline estimates suggest that a one-standard-deviation in rainfall increases the likelihood of conflict by around 13 percent. For households with tenure security the effect is significantly dampened. This highlights that tenure security leads to less conflict by reducing the vulnerability of rural household to rainfall anomalies. Guided with the theoretical predictions, we further document that factors increasing the marginal value of land magnifies the impact of water scarcity on conflict (without altering the positive effect of tenure security).

This paper is related to a vast empirical literature on how improved property rights affect economic outcomes. In reviewing the property rights literature, Besley and Ghatak (2009) detail how well-defined and secure property rights over land can impact economic outcomes. First, tenure security can increase investment incentives (Besley 1995, Fenske 2011) and it can also increase the use of land as collateral in accessing credit (Besley et al. 2012). Furthermore, there is evidence that political power use land tenure as a way to control the local economy. For example Goldstein and Udry (2008) show that in Ghana agents who are not central to the networks of local political power through which land is allocated are very likely to have their land expropriated if it is fallowed. This create incentive for intensive and inefficient use of land. Similarly, in a recent contribution Acemoglu et al. (2014) show that in Sierra Leone powerful chiefs control access to land. As a result, a whole series of development outcomes (educational attainment, child health among others) are significantly lower. Finally De Janvry et al. (2015), using the rollout of the Mexican land certification program from 1993 to 2006, show that land certification induces migration. We here document a new channel though which tenure security impacts economic outcomes: insecure property rights leada to conflicts, and potentially to violence, in dire times.

Our results also add new empirical evidences on an important channel through which weather anomalies can affect conflict[3]. It is generally found that rainfall anomalies are positively correlated with the occurrence of violent conflicts. We show here that tenure security is an important channel through which water scarcity translates into local conflict. It should be stressed that most of the existing empirical literature on this topic uses aggregate macro panel data on different African countries (see Blattman and Miguel, 2010, for a detailed review). In this paper we adopt a micro approach, allowing us to pin down a plausible mechanism translating weather anomalies in violence. To the best of our knowledge, the clear identification of the role of property rights in generating conflict is new in this literature.

Ethiopia provides a prime set up to address these types of research questions. A largely rural country, historically plagued by rainfall anomalies, Ethiopia's land rights were shaped by a radical land reform in 1975 implemented by the Marxist regime (the Derg). As a result, all land was made collective property of the Ethiopian people for more than three decades. Farmers were given usufruct rights (only user-rights to land) with periodic village-level land redistributions. Land could not be sold, mortgaged, exchanged, or transferred. While the new government in 1991 partially lifted the market ban and then allowed for some land rental activities, tenure security remained a critical issue. The momentum for more market oriented land policy was indeed very weak. A combination of oral contracts and lack of judicial institutions to intervene in case of disputes created a situation of persistent land insecurity, and frequent litigations among rural households (Deininger et al., 2008). The land certification program by providing clarity and tenure security aimed at reducing tenure insecurity resulting from the

[3]See for example Miguel et al., 2004; Harari and La ferrara, 2014; Couttenier and Soubeyran, 2014 or Berman and Couttenier, 2015.

previous usufruct land rights.[4]

The paper is organized as follows. Section 2 presents the theoretical framework and the main predictions. Section 3 describes the data while section 4 presents the empirical strategy and the results. Section 5 provides concluding remarks

2 Theoretical Framework

This section presents a simple theoretical framework in the spirit of the traditional property rights model presented in Besley and Ghatak (2009). The model provides an economic rationale for why conflict emerge in equilibrium and highlights the role of tenure security and of the marginal value of land. The model motivates the empirical model estimated in Section (4).

Environment Two agents $N = \{1, 2\}$ share a total amount of land of size L. Let x_1 be the land share of agent 1 and x_2 the share of agent 2, with $x_1 + x_2 = 1$. We denote by $l_1 = x_1 L$ the land size of agent 1 and by $l_2 = x_2 L$ the land size of agent 2. An amount of water w falls uniformly over L. Hence each agent has access to an amount of water $l_i w$.

Water is a substantial input in production (i.e. farming, herding) but also an essential part of agents livelihoods. We denote the payoff that each agent gets from an amount $l_i w$ of water by $b_i(l_i w)$. We assume that $b_i(.)$ is increasing and concave in the available amount of water $l_i w$.

Let v_i be the marginal value of land for each agent, i.e. $\frac{\partial b_i}{\partial li} = v_i$ for $i = 1, 2$. The utility of an agent i is $u_i = b_i(l_i w) + t_i$ where t_i is a monetary transfer. We

[4]Deininger et al. (2008) reports that self reported perceived tenure security increased and that the number of dispute over inheritance of land were reduced in the Amhara region after the implementation of the titling program. Holden et al. (2011a) find that the number of conflicts was lower both during and after the implementation of the land registration and certification than before.

assume that agents are expected-utility maximizers.

The game The agents bargain over a small piece of land owned by agent 1. Bargaining occurs naturally because the marginal value of land of agent 1 ("the owner") is lower than agent 2, i.e. $v_2 > v_1$. The game proceeds as follows: agent 1 makes an offer $\overline{p}$ to agent 2 for the piece of land. Agent 2 can either accept or refuse this offer. If agent 2 refuses the offer, he can either seize the land by force or start a (Nash) bargaining procedure. The bargaining procedure will lead agents to agree on a price p for the land such that $v_2 > p > v_1$. At this price the gains in utility from the transfer of land will be $(p - v_1)$ for agent 1 and $(v_2 - p)$ for agent 2[5].

If agent 2 contests the negotiation and decides to seize the land by force she has to incur a cost c. This cost reflects the legal formalities associated with the use of force, the social cost of potentially acquiring bad reputation... We assume that this cost is uniformly distributed[6] over $[0, \theta]$ and is private information of agent 2. The parameter θ summarizes the strength of property rights: a higher θ reflects that property rights are more strongly enforced in the region.

2.1 Analysis

We proceed by Backward Induction, first studying the outcome of the bargaining procedure.

The Bargaining procedure We are looking for the Nash Solution of the bargaining process, hence the p maximizing the Nash Product

[5] Note that the outcome of the game is qualitatively similar in the symmetric situation where agent 2 first makes an offer, which can be accepted or refused by agent 1, in which case agent 2 can either seize the land by force or start a Nash Bargaining procedure.

[6] We assume a uniform distribution for the sake of transparency. However, as will become clear while detailing the equilibrium, most of our results hold with more general distribution functions, in particular symmetric distributions with (weakly) decreasing hazard rates.

$$Max_p(p - v_1)^{\alpha_1}(v_2 - p)^{\alpha_2} \tag{1}$$

where α_1 and α_2 summarize the bargaining power of agent 1 and agent 2.

The first order condition leads to $\alpha_1(p - v_1)^{\alpha_1 - 1} = \alpha_2(v_2 - p)^{\alpha_2 - 1}$. Dividing both sides by $(p - v_1)^{\alpha_1 - 1}(v_2 - p)^{\alpha_2 - 1}$ and rearranging leads to

$$p^* = \frac{\alpha_1}{\alpha_1 + \alpha_2} v_2 + \frac{\alpha_2}{\alpha_1 + \alpha_2} v_1 \tag{2}$$

Note that, by construction, $v_1 \leq p^* \leq v_2$.

Decision of agent 2: conflict or peaceful negotiation Agent 2 compares the benefits of the initial offer and the bargaining price with the cost of seizing the land by force:

- If $\min\{\overline{p}, p^*, c\} = \overline{p}$ agent 2 accepts;

- If $\min\{\overline{p}, p^*, c\} = c$, agent 2 seizes land by force;

- Finally, if $\min\{\overline{p}, p^*, c\} = p^*$ agent 2 refuses the initial offer and starts bargaining.

The offer of Agent 1 The decision of agent 1 depends on θ and on the subsequent decisions highlighted above. Agent 1 first searches the p maximizing her expected payoff: $(1 - \mathbb{P}\{c \leq p\})(p - v_1) - (\mathbb{P}\{c \leq p\}) v_1$, leading to $p = \frac{\theta}{2}$ with a uniform distribution. We denote this solution by $p^{\max}$:

- If $p^{\max} \leq p^*$, *agent 1 offers* $\overline{p} = p^{\max}$. Any other initial offer decreases the expected payoff of agent 1 given that $p^{\max}$ maximizes the expected payoff of agent 1.

- If $p^{\max} > p^*$, *agent 1 offers* $\overline{p} = p^*$. If $\overline{p} > p^*$, agent 2 refuses the initial offer and starts the bargaining procedure which leads to p^* (if not seizing the land by force). Any offers $\overline{p} < p^*$ lead to a lower payoff for agent 1.

2.2 The Equilibrium

In the unique Perfect Bayesian Equilibrium of the game, the strategies of the agents are as follows: Agent 1's strategy is to

- propose $\overline{p} = p^{\max}$ if $p^{\max} \leq p^*$.

- propose $\overline{p} = p^*$ if $p^{\max} > p^*$.

Agent 2's strategy is to

- accepts any initial offer if $\min\{\overline{p}, p^*, c\} = \overline{p}$

- rejects the initial offer and seize the land by force if $\min\{\overline{p}, p^*, c\} = c$

- rejects the initial offer and starts the bargaining process if $\min\{\overline{p}, p^*, c\} = p^*$

Proposition 1 *In the unique Perfect Bayesian Nash equilibrium of the game, agent 1 offers $\overline{p} = \min\{p^{\max}, p^*\}$. Agent 2 accepts the initial offer if $\overline{p} \leq c$ and seize the land by force if $\overline{p} > c$.*

2.3 From theory to evidence

This simple framework can be used to obtain comparative statics predictions resulting from household level and water availability heterogeneity. We show that the probability of observing a conflict varies with strength of the property rights, and further depends on water scarcity, farm size and factors impacting the marginal value of land.

- More secure property rights are reflected as a higher θ: better property rights translate in a higher average value for c, the cost of seizing the land by force. Conflict occurs at the equilibrium when $\overline{p} = \min\{p^{\max}, p^*\} > c$. When $\overline{p} = p^*$, conflicts are less likely when θ is higher, simply because $\mathbb{P}\{c \leq p^*\} \equiv \frac{p^*}{\theta}$ decreases with θ. When $\overline{p} = p^{\max}$, the probability of conflict does not change when θ increases, $\mathbb{P}\{c \leq p^{\max}\} \equiv \frac{1}{2}$. Hence, we should observe that more secure property rights either diminish or have no impact on conflict[7].

- As shown above, the probability of conflict is increasing in p^* when $\overline{p} = p^*$, because $\mathbb{P}\{c \leq p^*\} \equiv \frac{p^*}{b}$. It is clear in equation (2) that an increase in v_1 and/or v_2 leads to an increase in p^*. Recalling that $\frac{\partial v_i}{\partial w} \geq 0$ due to the concavity of $b_i(l_i w)$, a decrease in the amount of water w will increase both v_1 and v_2, and ultimately p^*. Consequently, a decrease in the amount of water available to both agents increases the probability of conflict through an increase of the marginal value of land.

- Similarly, we can see that an increase in the amount of land available to one agent will decrease the probability of conflict: $\frac{\partial v_i}{\partial l_i} \leq 0$ due the concavity of $b_i(l_i w)$. Hence, if agent 1 (and/or agent 2) has more land at her disposition we should observe a drop in the probability of conflict.

- Finally, any factor increasing the marginal value of land will also increase the probability of conflict in dire times.

3 Data

3.1 Climatic Data

The climatic data are elaborated from the National Meteorological Services (2007), which provide annual mean rainfall from 1976 to 2006 at the household level. Rainfall data are collected from weather stations in the country. We impute the household specific rainfall values using longitude, latitude, and elevation

[7] This result holds for more general symmetric distributions (i) with (weakly) decreasing hazard rate and (ii) meeting the following condition: $f(p^{\max})^2 \frac{\partial F(p^{\max})}{\partial \theta} + \frac{\partial F(p^{\max})}{\partial \theta} \frac{\partial f(p^{\max})}{\partial p^{\max}}(1 - F(p^{\max})) - (1 - F(p^{\max}) f(p^{\max}) \frac{\partial f(p^{\max})}{\partial \theta} \leq 0$. Condition (ii) is met for most parameter values by the Normal distribution and the Student's t-distribution for example.

information of each household by adopting the *Thin Plate Spline* method of spatial interpolation, which is commonly used to generate spatial climate datasets[8]. This method has the advantage that it accounts for spatially varying elevation relationships, and it is not difficult to apply. However, it does not handle easily very sharp spatial gradients, and it only simulates elevation relationship. This is a typical characteristic of coastal areas. Significant terrain features, and no climatically important coastlines characterise our study area. This implies that the choice of the Thin Spline method is appropriate (for more details on the properties of this method see Daly, 2006).

We follow the recent literature and use rainfall anomalies as a measure of climatic anomalies, that is the difference between the weather at time t and the 1976-2006 climatic data divided by the 1976-2006 standard deviation. This allows for the possibility that drier areas having larger variability is taken into account, and the likelihood of scale effects is eliminated (Nicholson, 1986). This measure has been used by Barrios et al. (2010), who also emphasize that these anomalies can be considered as exogenous to the farm-household.

3.2 Land Use Conflicts

We use the Sustainable Land Management Survey to estimate the effect of climate on social conflicts and the role played by land tenure certification[9]. This is a farm-household panel survey conducted by the Department of Economics of Addis Ababa University in collaboration with the Ethiopian Development Re-

[8]By definition, Thin Plate Spline is a physically based two-dimensional interpolation scheme for arbitrarily spaced tabulated data. The Spline surface represents a thin metal sheet that is constrained not to move at the grid points, which ensures that the generated rainfall and temperature data at the weather stations are exactly the same as the data at the weather station sites that were used for the interpolation. In our case, the rainfall and temperature data at the weather stations are reproduced by the interpolation for those stations, which ensures the credibility of the method (see, Wahba 1990 for details).

[9]See Holden et al. (2011a), Deininger et al. (2011) for a background on Ethiopian tenure system.

search Institute, and the University of Gothenburg in years 2005 and 2007. The survey was conducted in the Amhara National Regional State of Ethiopia, and includes 12 villages (kebeles), six from the East Gojjam zone, and six from the South Wello zone. The Amhara region is one of the largest states of Ethiopia and is located in the northern, northeastern, and central areas of Ethiopia. It is the second largest state in the country covering eleven percent of Ethiopias total area. The Amhara region is divided into three major agricultural climatic zones: highland (above 2,300 meters), semi-highland (1,500 to 2,300 meters), and lowland (below 1,500 meters) accounting for 20%, 44%, and 28% of the land area, respectively. This varied ecology is also a source of diversified agriculture in the region. A large part of the population is living in highland areas with steep slope topography, and about 90% (14.7 million) of the people live in rural areas in the Amhara region.

The land registration and title certification pilot program was supported by the Swedish International Development Cooperation, as part of a rural development program for the Amhara region. A pilot was set up in two selected pilot kebeles Gozamen in East Gojam zone and Dessie Zuria in South Welo zone. While the original planning was to start the project in January 2003, it took about 30 months to complete data collection, data entry, and produce maps of the kebeles. The actual provision of certificates to the farmers in the pilot kebeles was postponed several times, and finally took place in March 2005. The treated group that randomly received land certification includes eight villages while the control group four villages. The randomization of property rights was at the village level. In addition, in each year about 1,500 households were selected by random stratified sampling based on indicators such as population density, access to the market, and agricultural potential.

One of the survey instruments was specifically designed to elicit land use conflicts. Specific questions were included to investigate whether farmers have

Table 1: Table 1 here

Table 2: Table 2 about here

experienced any conflicts: Have you ever faced any conflicts or claims regarding the land you own? An event was defined as a conflict in the following cases: (i) the claimant pushed the borders of the famers parcel; (ii) it was claimed that the plot was unfairly given to the farmer; (iii) it was claimed that the plot belonged to the claimant sometime ago; (iv) it was claimed that the farmer pushed the claimants borders; (v) the claimant did not want to leave the land the farmer left for him to manage while the farmer was away; (vi) the claimant did not want to leave the farmers land he had given out to him on sharecropping.

Our final sample includes 12 villages, and 1,487 farm-households (1,027 with land tenure and 460 without land tenure) for a total of 2,974 observations (2,054 with land tenure and 920 without land tenure). Descriptive statistics for the whole sample, and the control and treated groups are presented in Table 1. Table 1 shows that in year 2005 before the land certification was implemented our key variable of interest, the proportion of social conflicts, is not statistically different between control and treated group while in 2007 after the program implementation, farm-households belonging to the control group seem more likely to experience conflicts than the treated farm-households. In addition, Table 2 shows that control and treated villages are not statistically different, supporting the quality of the randomization of the land certification program at the village level.

As mentioned, the land certification program was randomly assigned at the village level. The villages in which the program has been implemented prior to the survey in 2007 are taken as the treatment group and the rest of the villages in our sample as the comparison group. As per the discussion with officials from the EPLAUA, the choice of the kebeles is based on a combination of factors such as the kebele's administrative capacity and the kebele's facilities. For the kebeles to be randomly chosen, it is required that the differences with respect to the kebeles administrative capacity is not strongly associated with other crucial kebeles features such as population, demography, agricultural potential, and the level of economic development. If the non-certified and certified kebeles are not systematically different in terms of factors that are likely to influence key economic variables of interest, then the sequential certification process could be considered random.

The primary criteria we used to establish that the choice of kebeles is random is the location of the kebeles relative to the main road/nearest town. As per our survey data, the average distance of the nearby town from treatment and control villages is 69.5 and 72.5 minutes, respectively. Similarly, the average distance from a nearby main road is 24 and 37 minutes, respectively. This shows that, there is no pattern which makes the certified and non-certified kebeles significantly farther or nearer from the main road. These findings lend support to our assumption that the differential temporal treatment of the program across the different kebeles can be taken as a quasi-experiment to identify the causality between the program and the changes in the outcome of interest.

Test of the common trend assumption is considered a more formal test of random assignment of the program into treatment and control kebeles. Given that the common trend assumption holds, the general trend in the variable of interest in the two groups (treated and not treated) would have been the same in the absence of treatment. While the common trends assumption is fundamentally untestable after the introduction of the program, previous studies assess the pattern of pre-policy changes in various variables of economic interest to validate the assumption (e.g. Deininger et al., 2011). In these studies, the common trend assumption was conducted based on the three-wave observations prior to the commencement of the program, effective after the year 2005.

4 Empirical Strategy and Results

We now turn on the empirical investigation of the theoretical predictions presented in section (2). We will detail our empirical strategy before presenting our results.

4.1 Empirical Strategy

Our empirical strategy relies on (i) the random nature of rainfall anomalies; (ii) the random assignment of land certification to farm-households at the village level; and (iii) the panel nature of our dataset by using farm-household and time fixed-effect.

First, we estimate

$$Y^*_{i,t} = \beta_1 W_t + \beta_2 W_{t-1} + \beta_3 Tenure + \epsilon_{1,i,t} \tag{3}$$

where Y^* represents the unobserved propensity of farm-household i in year t ($t = 2005, 2007$) to experience land use conflicts; W represents rainfall anomalies experienced by farm-household i at times t and $t-1$ to allow for the dynamic effect of climatic factors[10]; $Tenure$ is a dummy equal to one if a household has secure property rights over land and ϵ is the individual error term.

We then exploit the panel nature of the dataset and compare the same household overtime subject to different climatic conditions accounting for time-

[10] We consider one lag following the existing literature (e.g., Couttenier and Soubeyran, 2014 or Harari and La Ferrara, 2014).

invariant and time-specific omitted variables [11]

$$Y^*_{i,t} = \beta_1 W_t + \beta_2 W_{t-1} + \mu_i + \mu_t + \epsilon_{2,i,t} \tag{4}$$

where μ_i represents farm-household fixed effects and μ_t represents the time fixed effect. Finally, we want to see if household with land tenure security are less prone to conflict triggered by water scarcity,

$$Y^*_{i,t} = \beta_1 W_t + \beta_2 W_{t-1} + \beta_3 W_t \times Tenure + \beta_4 W_{t-1} \times Tenure + \mu_i + \mu_t + \epsilon_{3,i,t} \tag{5}$$

where $W_t \times Tenure$ and $W_{t-1} \times Tenure$ denote the interaction of rainfall anomalies with the dummy $Tenure$.

As mentioned, Y^* is not observed. What we do observe is whether the farm-household faced any conflicts related to the land owned. Hence, following the theoretical framework, the mapping from Y^* to the observable $Y_{i,t}$ is

$$Y_{i,t} = \begin{cases} 1 \text{ if } Y^* > 0, \\ 0 \text{ otherwise} \end{cases} \tag{6}$$

where $Y_{i,t}$ is equal to 1 if the farm-household experienced any conflicts and 0 otherwise. In addition, we account for within-panel autocorrelation (clustering on farm-households) and cross-panel correlation (clustering on time) by estimating two-way cluster-robust standard errors (Cameron et al., 2011).

In addition to the equations above, we estimate alternative specifications that include interaction terms. Following our theoretical predictions, the prime objective is to shed light on the mechanism linking water shock, property rights and conflicts. First we introduce an interaction term involving rainfall anomalies and the farm size (i.e. land size l_i in the model). We include this interaction

[11] Of course, in order to account for fixed effects we have to drop the variable "Tenure".

to explore the prediction 3 stating that when the share of land of the owner is higher, the probability of conflict should be lower when hit by a water shock (due to a lower marginal value of land). The expected sign of the interaction term is positive: we should observe less conflicts after a drop in water availability when the owner has more land. We also consider if having more labor available on the farm (i.e. proxied by household size) or having more livestock would increase the impact of water scarcity on conflict (as predicted by the theoretical framework). The main idea is that having more of these factors—crucial for farming and herding—will increase the marginal value of land. We thus expect a negative sign for these interactions terms.

4.2 Main Results

Table 3 presents standard OLS estimates of equation (4), (5) and (6) with robust standard errors clustered at the kebele level[12]. As expected, column (1)-(3) show that tenure security reduces conflict. Furthermore, we see in columns (2)-(6) that (i) rainfall anomalies increase the likelihood of conflicts; and (ii) that farm-households with land certification are resilient to rainfall anomalies.

In terms of magnitude, the estimation results in Table 3 suggest that having tenure security reduces the occurrence of conflict by around 5 percent. Conversely, a one-standard-deviation decrease in rainfall (signaling drier conditions) increases the probability of observing a conflict for the average household by around 13 percent. Columns (4)-(6) conclude by showing that tenure security dampens conflict by reducing the vulnerability of household to weather variation: the effect of tenure security on conflict transits mostly through a reduction in clashes triggered by water scarcity.

[12]Although our dependent variable is dichotomous, we choose to implement OLS because alternative models such as logit and probit models may yield to biased estimates in the case of rare events as in our case study (King and Zheng, 2001; Harari and La Ferrara, 2014).

Table 3: Main Results

	(1) Conflict	(2) Conflict	(3) Conflict	(4) Conflict	(5) Conflict	(6) Conflict
Tenure Security	-.040^a	-0.043^a	-0.062^a			
	(0.014)	(0.014)	(0.014)			
Rainfall Anomalies$_t$		-0.032^c	-0.091^a	-0.123^a	-0.124^a	-0.138^a
		(0.019)	(0.024)	(0.035)	(0.035)	(0.042)
Rainfall Anomalies$_{t-1}$			-0.200^a		-0.139	-0.103
			(0.041)		(0.086)	(0.086)
Rainfall Anomalies$_t$ $\times$Land Tenure						0.062
						(0.069)
Rainfall Anomalies$_{t-1}$ $\times$Land Tenure						0.324^a
						(0.121)
Household Fixed Effect	no	no	no	yes	yes	yes
Year Fixed Effect	no	no	no	yes	yes	yes
N	3507	3507	3507	3448	3448	3448

Note: Two way clustered robust standard errors in parentheses. ^{c} significant at 10%; ^{b} significant at 5%; ^{a} significant at 1%.

4.3 Further Interactions

Having identified the effect of water scarcity on land conflicts and the dampening effect of tenure security, we are now interested in studying further the possible mechanism linking these variables. Following Section 2, we first investigate if having more available land decreases the impact of water scarcity on conflict (prediction 3). Conversely, we suspect that weather stress has a bigger impact on conflict when the marginal value of land is more important (prediction 4). We will thus investigate if water scarcity has a larger impact on conflict if the household size is bigger (a proxy for more available labor) or if the farm has more livestock.

Table 4 presents results when we include these interactions terms. Column (1) shows results when we include Rainfall anomalies $\times$ Farm Size. As predicted, having more land significantly dampens the effect of water scarcity on conflict (presumably because it reduces the marginal value of land for the owner). Columns (2) and (3) present results when we include the interactions terms Rainfall anomalies × Household size and Rainfall anomalies × Livestock. We observe a negative relationship between the interaction of actual water scarcity with household size and livestock. It is noteworthy that in all these specifications (i) rainfall anomalies significantly impact conflict and (ii) land tenure dampens this effect.

Table 4: Role of marginal value of land

	(1) Conflict	(2) Conflict	(3) Conflict
Rainfall Anomalies$_t$	-0.148^a	-0.064	-0.126^b
	(0.043)	(0.048)	(0.042)
Rainfall Anomalies$_{t-1}$	-0.140	-0.095	-0.110
	(0.088)	(0.090)	(0.087)
Rainfall Anomalies$_t$ ×Land Tenure	0.044	0.054	0.072
	(0.069)	(0.068)	(0.068)
Rainfall Anomalies$_{t-1}$ ×Land Tenure	0.295^b	0.325^a	0.347^b
	(0.121)	(0.119)	(0.118)
Rainfall Anomalies$_t$ ×Land Size	0.024		
	(0.040)		
Rainfall Anomalies$_{t-1}$ ×Land Size	0.142^a		
	(0.048)		
Rainfall Anomalies$_t$ ×Household Size		-0.109^c	
		(0.059)	
Rainfall Anomalies$_{t-1}$ ×Household Size		0.025	
		(0.063)	
Rainfall Anomalies$_t$ ×Livestock			-0.126^b
			(0.042)
Rainfall Anomalies$_{t-1}$ ×Livestock			0.110
			(0.087)
Household Fixed Effect	yes	yes	yes
Year Fixed Effect	yes	yes	yes
N	3448	3448	3448

Note: ^{c} significant at 10%; ^{b} significant at 5%; ^{a} significant at 1%.

In sum, we consistently find that actual water conditions have a stronger impact on the level of conflict when the marginal value of land is bigger: either because there is more labor or more livestock available in the farm, or because there is less land available in the first place. These findings are supportive of the intuitions developed in the model presented in section 2: water scarcity increases the marginal value of land, which in turns increases the temptation to rely on violence instead of peaceful bargaining in difficult times.

4.4 Alternative Mechanism

We take the view in this paper that water scarcity increases the propensity to rely on violence through a rise in marginal value of land. Property rights dampen this effect by increasing the cost of seizing the land by force. Another plausible mechanism in the literature highlights the role of income shock in triggering conflict: agents fight over a dwindling resource because of a strong and unexpected drop in income. If well-defined property rights allow to smooth income over time, they would also limit conflict. The literature on the "De Soto" effect (Besley et al., 2012) points out that well-defined property rights can facilitate access to credit because fixed assets can be used as collateral. While this would not invalidate the link between tenure and conflict, it refers to a completely different mechanism. In particular, it would imply that credit constraints were the critical factor behind violence.

We distinguish between these mechanisms by using the information available on access to credit by each household. We investigate if weather stress has a lower effect on land conflict when the household size has access to credit. It is purported that access to credit allows to smooth income and may thus dampen the effect of weather shock. Table 5 presents the result including the interaction terms Rainfall anomalies$\times$Access to Credit. We find no direct evidences supporting the "credit" channel, while the interaction Water Scarcity$_{t-1}$ $\times$Land Tenure stays significant.

Table 5: Access to credit

	(1) Conflict
Water Scarcity$_t$	-0.127^b
	(0.043)
Water Scarcity$_{t-1}$	-0.105^a
	(0.088)
Water Scarcity$_t$ ×Land Tenure	0.063
	(0.069)
Water Scarcity$_{t-1}$ ×Land Tenure	0.332^c
	(0.120)
Water Scarcity$_t$ ×Credit	-0.058
	0.048)
Water Scarcity$_{t-1}$ ×Credit	0.004
	(0.052)
Household Fixed Effect	yes
Year Fixed Effect	yes
N	3442

Note: ^{c} significant at 10%; ^{b} significant at 5%; ^{a} significant at 1%.

5 Concluding remarks

Recent literature presents robust evidence that well-defined property rights over land have an impact on many economic outcomes. In this paper, we present a simple model of land conflict and use a large panel dataset from Ethiopia to investigate whether land certification could lessen the effects of water scarcity on land use conflicts. We compare the same household overtime subject to different rainfall anomalies. Our identification strategy relies on the exogenous variation in rainfall anomalies, and the random assignment of land certification at the village level.

First, we find that well defined property rights decrease the likelihood of conflicts. Second, in line with the previous literature, we find that rainfall anomalies increase the likelihood of conflicts. Then, we highlight that land certification decreases the effect of water scarcity on conflicts. Finally, we show that actual water conditions have a stronger impact on the level of conflict when the marginal value of land is bigger: either because there is more labor or livestock available in the farm or because there is less land available in the first place. Our results are robust to different specifications, and suggest that land certification is an effective policy instrument to buffer against climate anomalies. The policy implications of this paper are potentially very large. Policies that strengthen property rights over land besides creating a precondition for economic growth and development may also reduce the likelihood of conflicts triggered by environmental challenges. Secure property rights to land can have a profound effect on incentives and on the working of markets for land and on welfare in general.

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