Violent Conflict and Farming Decision: Evidence from Burundi

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Abstract

Civil wars cause economic underperformance and poverty. In this paper, we theoretically and empirically examine how exposure to violence shapes farming decisions and consequently welfare of farming households, and how this mechanism leads to a poverty trap in Burundi. We combine a nationwide household survey on agricultural activities with geo-referenced data on conflict events in Burundi. We demonstrate that exposure to protracted violence discourages farmers from diversifying crop portfolio, which is welfare-diminishing. Although crop diversification is an optimal risk-mitigating strategy for Burundian farmers, food insecurity exacerbates the constraints that the farmers confront, limiting their ability to efficiently allocate resources. The difference between the long and short term effects of conflict suggests that the impacts of violence depreciate and adaptation takes place over time. However, the adaptation reinforces poverty pushing the war-vulnerable farmers into a poverty trap.

Keywords: Agriculture, Farming Household, Risk-mitigating Strategies, Poverty trap, Conflicts, Civil War, Burundi, Africa

JEL Classification: Q10, Q12, D13, D81, D90

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1 Introduction

Civil conflict pushes a country into a trough of economic underperformance and poverty (Collier, 1999; Collier and Hoeffler, 1998; Arunatilake et al., 2001; Blattman, 2010).[1] In many Sub-Saharan African countries, sluggish economic development was attributed to protracted civil wars since 1990s. Agricultural production is the key for the region's economy because on average, 15% of the GDP comes from and two thirds of the population is employed in the agricultural sector in Africa. Particularly in East and Central Africa, agricultural production has been thwarted by prolonged conflict and political instability. Due to the stagnant improvement in agricultural productivity, food insecurity is prevalent in the rural areas in Africa (NEPAD, 2013).

The main objective of this paper is to theoretically and empirically examine impacts of protracted civil wars on behavior of farmers in the choice of farming strategies, and how this choice affects their welfare in Burundi. In the first part of the paper, we establish a household model of a farmer's choice of labor allocation to activities with different degrees of riskiness. We derive predictions concerning patterns of diversification under constant risk of renewed fighting. The optimal choice of labor inputs depends on production risk, labor availability, and restrictions on food supply. Poor farmers make production decision dependent on their consumption, and have limited ability to cope with income shocks. We particularly pay attention to a self-reinforcing poverty trap in which food insecurity is a driving factor that links exposure to violence with failure in adoption of an optimal risk-mitigating strategy. An increase in the production risk and limited labor availability due to protracted violence discourage farmers to diversify crops, and food insufficiency aggravates the marginal conditions of small scale farmers. The model proposes that exposure to intense conflict has negative impacts on welfare of the affected reducing consumption level. However, this negative effect can be mitigated for farmers with more assets.

In the second part of the paper, we empirically show that cropping practices of Burundian farmers are consistent with the implications of the model. We combine a nationwide household survey on agricultural activities (ENAB 2011-2012) with the geo-referenced data on timing and

[1] Murdoch and Sandler (2004) find that civil wars reduce a country's growth by 85% in the first five years, while recovery growth is still reduced by 31% after 35 years.

locations of conflict events (ACLED) in Burundi. The identification strategy exploits variations in conflict intensity and related variations in outcomes because violence in Burundi was indiscriminate, and near exogenous to household and regional characteristics (Voors et al., 2012; Uvin, 1999). The baseline estimations is done for the whole period between 1997 and 2010.[2] We then divide the period into earlier (1997-2005) and later (2006-2010) periods to compare the long- and short-term effects of violence. Lastly, we conduct various robustness checks and sensitivity analyses. We use an instrument variable approach to address the potential endogeneity of conflict intensity.

This paper expands two strands of the existing literature. The first strand of literature is microeconomic analysis of consequences of violent conflict. Studies estimate the effects of war on socio-economic outcomes such as consumption (Ibáñez and Moya, 2010; Serneels and Verpoorten, 2015; Arcand and Wouabe, 2009; Rockmore, 2011), poverty (Justino, 2009), inequality and health (Bundervoet et al., 2009; Akresh et al., 2012; Minoiu and Shemyakina, 2012), education (Akresh and De Walque, 2008; Shemyakina, 2011), and investment (Deininger, 2003; Grun, 2008). The second body of literature to which this paper relates is on risk-mitigating strategies of farming households in developing countries (Fafchamps, 2003; Kurosaki and Fafchamps, 2002). Farming households adopt strategies to mitigate risks and uncertainty. The most commonly adopted risk-mitigating strategy of poor farmers in the face of various types of risks is diversification of income sources (Reardon et al., 1992; Block and Webb, 2001; Brück, 2004).

The novelty of this paper is twofold. First, this paper contributes to identify adaptation in farming strategies as a consequence of exposure to violent conflict. There is a wide range of literature on the two topics separately, but less is known about the relationship between violent conflict and farming strategies.[3] Second, we attempt to bridge the gap between country level analysis of the conflict-poverty trap and its parallel implications at individual level by combining theory and empirics. Cross-country studies on the relationship between violence and economic underperformance are available, whereas little research has been done on microeconomic analysis of a vicious cycle of violent conflict and poverty through agricultural decisions. We complement this research with focus on food insecurity that exacerbates constraints that

[2] The conflict dataset, ACLED, provides the information on conflict events for the period between 1997 and 2014.

[3] The literature that links conflict with farming strategy is scarce. A recent paper is Paul et al. (2015) which find that the net effect of conflict on crop diversification is positive but not significant in the study of Cote d'Ivoire.

poor farmers confront as a channel through which violent conflict affect farming decisions.[4] We find that war-vulnerable farmers are less likely to diversify their crop portfolio. The negative effect of exposure to violence is larger and significant for farmers who live under the poverty line. Since polyculture is technically more efficient, this adaptive response to violence towards less crop diversification is welfare diminishing. However, the negative effect of the conflict intensity on their welfare is effectively mitigated by household assets. On the other hand, farmers exposed to more intense violence are likely to participate in non-agricultural activities in the long run, but the result is not statistically significant. We also find that long-term adaptation differs from short-term responses. This difference suggests that predominant risk factors change, impacts of violence depreciate, and adaptation takes place over time. The results from the robustness check and sensitivity tests are consistent with the baseline estimation.

The paper is organised as follows. The next section provides stylized facts concerning Burundi. Section 3 presents the theoretical framework. Section 4 discusses the data. In Section 5, empirical analyses and results are discussed. Section 6 confirms the robustness of the results and discusses some issues. Section 7 concludes the paper.

2 Stylized Facts about Conflict and Agriculture in Burundi

Burundi is the third poorest country in the world with the highest hunger score, and is ranked the ninth in food security crisis in 2018.[5] Almost 80% of its population was classified as income poor living under the poverty line of $1.90 a day in 2015.[6] Several facts about Burundi make the country an interesting empirical setting for sub-national and disaggregated analysis of the effects of violent conflict.

[4] There was a worsening effect of a poverty trap caused by long term food insecurity in the two densely populated provinces of Burundi in the pre- and post-war periods (D'Haese et al., 2010).

[5] Food Security Information Network, *Global Report on Food Crises* (2018)

[6] Oxford Poverty and Human Development Initiative (OPHI), *Country Briefing December 2015: Burundi*, (Oxford Department of International Development, 2018).

2.1 Conflict and Poverty

Burundi saw a dramatic drop in economic growth since early 1990s when the violence was most severe nationwide.[7] Figure 1 presents the change in GNI per capita of Burundi between 1980 and 2016. Per capita GDP declined from $163 in 1993 to $149 in 2005, and this period of sluggish economic growth has overlapped with the period of the most severe civil wars since the eruption of recent violence in 1993. The country has experienced violent conflict with geographical variations in its intensity for more than a decade. Households in different regions were exposed to different degrees of violence. Figure 2 displays two maps of Burundi which show the conflict intensity measured with the number of conflict events and the associated fatalities respectively aggregated at community level. Violence was more concentrated near the former capital, Bujumbura, and the neighboring provinces, and along the lake Tanganyika towards the Southern provinces.

The country's economy was stymied by the reduction in its agricultural production. Agricultural production is the most important income source of the country as 85% of the population are engaged in the agricultural sector, and nearly 80% of its land area is devoted to agriculture in 2017.[8] However, the prolonged civil war caused inefficiency in agricultural production in Burundi.[9] The food crop production in 2005 was only about 62% of the pre-conflict level, and the decrease was even worse in terms of per capita unit with 45% of the 1993 level. Even after 2005, the growth of the agricultural sector was still slow with the annual rate below 3% between 2006 and 2010 (Niragira et al., 2013). This substantial drop in the agricultural production between 1990s and 2000s has consequently led to widespread poverty, food insecurity, and consequential hunger and malnutrition of the population.[10] The proportion of people living under poverty line increased from 35% in early 1990s to 68% in 2002 (D'Haese et al., 2010).

7 The long history of violence in Burundi dates back to 1965, three years after independence from the Belgian colonialism. The failure of the Hutu officers' attempt to seize power started the political monopoly of the Tutsi minority over the majority of the Hutu. Since then, Burundi experienced episodes of ethnic driven violent conflicts nearly for four decades. The recent most intense violence erupted three months after the assassination of the first ever elected Hutu president, Melchior Ndadaye, in 1993. More than 300,000 civilians were killed and displaced 1.2 million people were displaced within weeks. The civil wars began to spread throughout the country in 1994, and continued nationwide between 1994 and 2005.

8 2,033,000 out of 2,568,000 hectares of the land area is for agricultural use.(FAO)

9 Agricultural production substantially decreased between 1993 and 1998, when the production of cereals declined by 15%, roots and tubers by 11%, and fruits and vegetables by 14% (Bundervoet, 2007).

10 In the study conducted in 2007, 75% of the households interviewed rated themselves as highly food insecure (D'Haese et al., 2010).

More than 50% of children in the country were stunted, and more than 50% of the population is chronically food insecure: total annual production of food would only cover for 55 days per person per year in 2016 (Food and Organization, 2017).[11]

2.2 Farming Practice

There are certain contexts which characterize farming practices of Burundian farmers. First, production and consumption decisions of farming households are not separable. Small scale farmers are both producers and consumers. A Burundian household on average consumes 72% of its farm production, and the rest is marketed or exchanged through social networks (Niragira et al., 2015). Many studies document the non-separability of production and consumption of farmers in developing countries (Yutopoulos and Lau, 1974; Lopez, 1986; De Janvry et al., 1991; Benjamin, 1992; Fafchamps and Quisumbing, 1999; Jacoby, 1993; Udry, 1996; Arcand and d'Hombres, 2011). The presence of market failures leads to non-separability of production and consumption decisions for rural households.[12] If production and consumption are simultaneous, the shadow price of a good is endogenously determined by demand and supply of households, and thus is different from its market price. One way to test non-separability is to check whether household characteristics influence labor demand. When labor markets are incomplete, family and hired labor are not perfect substitutes. In the simple separability test in Table 1, the result shows that the composition of the household affects the demands of total labor, hired labor, and aid labor inputs per hectare on a plot, rejecting the separability between production and consumption of farmers in Burundi. We confirm that production decisions are not independent of consumption decision of farming households in Burundi.

[Table 1 is here]

Second, a majority of Burundian farmers are involved in small scaled and subsistence farming due to land scarcity. Burundi is one of the smallest countries in Africa with a highly dense population.[13] The average farm size in Burundi is substantially small compared to other countries in Sub-Saharan Africa. Table 2 shows the average farm size in some of African countries. The

11 FAOSTAT, http://www.fao.org/faostat/en/country/29

12 A farm household that produces food and cash crops faces two market failures: one in the food market and the other in the labor market.

13 Burundi is a tiny country with the third highest population density in Africa of 1,040 persons per square mile.

average plot size in the sampled households in Burundi is 0.041 hectares, which is almost one tenth of the average farm size of Malawi. Burundian farmers thus by and large are small scale farmers engaged in intensive and subsistence-oriented farming on highly fragmented family farms and lack other opportunities outside the agricultural sector. This has resulted in high rates of self-reliance and highly diversified mixed cultivation.

2.3 Crop Diversification as a Risk-Mitigating Strategy

Since most of farms are small scale due to land scarcity, cultivating multiple crops on a plot is a norm in Burundi. Polyculture is bascially a prevalent form of risk-mitigating strategies of farmers in developing countries. Diversifying a crop portfolio reduces economic losses due to diseases, increases soil fertility and nutrition diversity through crop rotation, and lowers potential production risk by reducing high dependency on a particular crop (Krupinsky et al., 2002).

To answer the question of whether polyculture is beneficial as a risk-mitigating strategy in the Burundian context, we estimate technical inefficiency using a stochastic frontier production function.[14] In measuring the output oriented technical inefficiency, the objective is to maximize output as the only choice variable with exogenously given inputs. All deviations from the maximum output are ascribed to inefficiency. In other words, technical inefficiency indicates the difference between the actual output and the maximum level of output given the level of inputs (Farrell, 1957). In our estimation, the inputs are the size of the plot and the number of total labor per plot. We assume that other inputs (seeds and fertilizer etc.) are proportionate to the size of the plot. Table 3 presents the estimated technical inefficiency by the number of crops cultivated in the plot. The higher the number of crops per plot is, the smaller the technical inefficiency of the production is in a plot. Figure 3 shows the estimated kernel density of the technical inefficiency of polycultural and monocultural plots. The distribution of technical inefficiency for monocultural plots is more right-skewed than that for polycultural plots. The two results prove that in Burundi, crop diversification is technically efficient so that farmers

[14] There is conflicting evidence concerning the efficiency achieved through crop diversification. Some studies demonstrate that crop diversification significantly improves technical efficiency of farms in developing countries such as Vietnam, India, Bangladesh, Nigeria, and Papua New Guinea (Nguyen, 2014; Manjunatha et al., 2013; Ogundari, 2013; Rahman, 2009; Coelli and Fleming, 2004). In contrast, others find no significant relationship between crop diversification and technical efficiency (Haji, 2007), or a reduction in efficiency due to crop diversification (Llewelyn and Williams, 1996).

enjoy efficiency gains from cultivating many crops in a given plot. This implies that crop diversification is beneficial, and a failure in adopting the productive strategy can be attributed to a hindrance to adequate farming decisions.

3 Theoretical Framework

This section describes a household model where a Burundian farmer makes decisions of allocation of labor under uncertainty during or in the aftermath of protracted violent conflicts.[15] As the farmer operates a farm under marginal conditions and incomplete markets, the model makes the following assumptions which are consonant with a low-income agricultural environment: (i) a unitary decision maker in a household, (ii) non-separation of production and consumption decisions of a farmer, and (iii) the risk that affects returns to the agricultural production. A head of household chooses to allocate its endowed labor to multiple activities with different level of riskiness according to the household's objectives.

3.1 Model

3.1.1 Production and Consumption of Farming Household

A household is endowed with fixed labor time denoted by Ω, used for three types of activities - two farming activities involving a certain level of risk, and one risk-free activity outside the farm. The labor inputs L_1 and L_2 are allocated to the two farming activities, and H is allocated to the risk-free activity.

$$\Omega = L_1 + L_2 + H$$

In simplicity, labor is the sole input in a given plot. The production function, $f_a(L_a)$ $(a = 1,2)$, is twice differentiable, and quasi-convex where $f_a'(L) > 0$ and $f_a''(L) \geq 0$. The uncertainty in the income from agricultural activities stems solely from production risk. Outputs for the two

15 We formulate a household model based on the household model in Benjamin (1992).

risky activities are given by

$$y_1 = \theta_1 f_1(L_1), \qquad y_2 = \theta_2 f_2(L_2)$$

when

$$(\theta_1, \theta_2) \sim N((\mu_1, \mu_2), \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix})$$

where $\mu_1 > \mu_2$ and $\sigma_1 > \sigma_2$.

Household consumption depends on its income from the three activities. Considering the credit constraint in rural communities in Burundi, we exclude the possibility of using alternative sources for consumption (This will be expanded later). As markets are incomplete, and thus production and consumption are not separable, we assume the internal shadow price determination condition in which the household demand for a good equals its output (Strauss, 1986; De Janvry et al., 1991). The return to the two risky activities are normalized to one given by:

$$c = y_1 + y_2 + wH$$

where c represents household consumption and w is the returns to the risk-free activity (i.e. the wage rate).

3.1.2 Farmer's Problem

Under non-separability of production and consumption, the farmer's problem is to maximize the expected utility under their budget constraint.

$$
\begin{aligned}
&\max_{L_1,L_2} \quad \mathbb{E}u(c) \quad \text{s.t} \quad c = y_1 + y_2 + wH \\
&\quad \text{where} \quad y_1 = \theta_1 f_1(L_1), \quad y_2 = \theta_2 f_2(L_2) \\
&\quad \text{and} \quad \Omega = L_1 + L_2 + H \\
&\quad f_1(L_1) \geq 0 \qquad f_2(L_2) \geq 0 \qquad L_1 \geq 0 \qquad L_2 \geq 0
\end{aligned}
$$

The utility function of the household, $u(c)$, is twice continuously differentiable and concave defined over consumption with $u'(c) > 0$ and $u''(c) \leq 0$.

3.1.3 Assumptions on Functional Forms and Riskiness of Activities

I make the following assumptions for analytical convenience.

Assumption 1. *The utility function takes a CARA form.*

$$u(c) = -exp\{-\gamma c\},$$

where γ is the Arrow-Pratt coefficient of absolute risk aversion.

Assumption 2. *Outputs of the two activities are linear in the labor input.*

$$
\begin{aligned}
f(L_1) &= (1-\kappa)L_1, \\
f(L_2) &= (1-\kappa)L_2,
\end{aligned}
$$

where κ is a technical inefficiency of production ($0 \leq \kappa < 1$).

$$
\kappa = \begin{cases} 0, & \text{if } L_1L_2 > 0 \\ \kappa_0 \qquad (0 < \kappa_0 < 1), & \text{if } L_1L_2 = 0 \end{cases} \tag{1}
$$

As shown in the section 2.3, monoculture involves a certain level of inefficiency κ_0.

Assumption 3. *The first farming activity is riskier than the second farming activity, and the outputs* *of the two activities are correlated.*

$$\sigma_1 = \sigma, \qquad \sigma_2 = \alpha\sigma \qquad \alpha \in (0,1), \qquad \sigma_{12} \neq 0.$$

To avoid corner solutions in which the farmer could allocate all of her labor endowment to the risk-free activity, I make the usual portfolio choice assumption that:

Assumption 4. *The return to the risk-free activity is lower than the average returns of the two risky activities.*

$$w < \mu_2(1-\kappa) < \mu_1(1-\kappa)$$

This assumption reflects the situation of farmers in rural areas in a developing country. The (relative) return to the risk-free activity is likely to be low because of incomplete markets of inputs and outputs, and limited opportunities outside the agricultural sector.

3.2 Optimal Allocation of Labor

By the usual properties of the moment-generating function for lognormal distribution, the household's objective function is given by:

$$\mathcal{L} = -\exp\{-\gamma[w(\Omega - L_1 - L_2) + \mu_1(1-\kappa)L_1 + \mu_2(1-\kappa)L_2] + \frac{\gamma^2\sigma^2(1-\kappa)^2}{2}(L_1^2 + 2\alpha\rho L_1 L_2 + \alpha^2 L_2^2)\}$$
$$- \lambda_1 L_1 - \lambda_2 L_2$$

where λ_1 and λ_2 are Lagrange multipliers and ρ is the correlation of the risks from the two activities, $\rho = \frac{\sigma_{12}}{\sigma_1\sigma_2}$. Details are presented in Appendix C.1.

Proposition 1. *There exists the optimal labor allocation which responds to the changes in ρ and α. When ρ is high, a farmer is reluctant to diversify. Depending on the level of α, the farmer may allocate labor to either of the risky activities. If $0 < \alpha \leq \frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w}$ and $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$, the optimal* *allocation of labor is*

$$L_1^* = 0$$
$$L_2^* = \frac{\mu_2(1-\kappa_0) - w}{\gamma\alpha^2\sigma^2(1-\kappa_0)^2}$$
$$H^* = \Omega - \frac{\mu_2(1-\kappa_0) - w}{\gamma\alpha^2\sigma^2(1-\kappa_0)^2}$$

If $\frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w} < \alpha \leq 1$ *and* $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$*, the optimal allocation of labor is*

$$L_1^* = \frac{\mu_1(1-\kappa_0) - w}{\gamma\sigma^2(1-\kappa_0)^2}$$
$$L_2^* = 0$$
$$H^* = \Omega - \frac{\mu_1(1-\kappa_0) - w}{\gamma\sigma^2(1-\kappa_0)^2}$$

If ρ *is low, a farmer diversify her crop portfolio into two risky activities. If* $0 < \alpha \leq \frac{\mu_2-w}{\mu_1-w}$ *and* $-1 \leq \rho \leq \frac{\alpha(\mu_1-w)}{\mu_2-w}$*, or* $\frac{\mu_2-w}{\mu_1-w} < \alpha \leq 1$ *and* $-1 \leq \rho \leq \frac{\mu_2-w}{\alpha(\mu_1-w)}$*, the optimal allocation of labor is*

$$L_1^* = \frac{\alpha(\mu_1-w) - \rho(\mu_2-w)}{\gamma\alpha\sigma^2(1-\rho^2)}$$
$$L_2^* = \frac{(\mu_2-w) - \alpha\rho(\mu_1-w)}{\gamma\alpha^2\sigma^2(1-\rho^2)}$$
$$H^* = \Omega - \frac{(1-\alpha\rho)(\mu_2-w) + \alpha(\alpha-\rho)(\mu_1-w)}{\gamma\alpha^2\sigma^2(1-\rho^2)}$$

Proof. See Appendix C.2 ■

Proposition 1 states that a risk averse farmer who faces high level of covariate risks in the outputs of the two farming activities specializes in one activity. This decision depends on the difference in the level of riskiness of the two risky activities. On the other hand, if there is negative or low covariate risks in the production from the two activities, she prefers diversifying her farming activities. The effectiveness of diversification as a strategy to respond to income risk therefore depends on the variance and covariance between the different income sources.

3.3 Decision-Makings in the Context of Protracted Conflicts

3.3.1 Change in Optimal Allocation of Labor

Proposition 2. *The optimal labor inputs to the two risky farming activities decrease in response to an increase in σ.*

If $0 < \alpha \leq \frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w}$ and $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$,

$$\frac{\partial L_2^*}{\partial \sigma} < 0 \qquad \frac{\partial H^*}{\partial \sigma} > 0$$

If $\frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w} < \alpha \leq 1$ and $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$,

$$\frac{\partial L_1^*}{\partial \sigma} < 0 \qquad \frac{\partial H^*}{\partial \sigma} > 0$$

If $0 < \alpha \leq \frac{\mu_2-w}{\mu_1-w}$ and $-1 \leq \rho \leq \frac{\alpha(\mu_1-w)}{\mu_2-w}$, or $\frac{\mu_2-w}{\mu_1-w} < \alpha \leq 1$ and $-1 \leq \rho \leq \frac{\mu_2-w}{\alpha(\mu_1-w)}$,

$$\frac{\partial L_1^*}{\partial \sigma} < 0 \qquad \frac{\partial L_2^*}{\partial \sigma} < 0 \qquad \frac{\partial H^*}{\partial \sigma} > 0$$

Proposition 2 states that when a farmer faces a higher ex-ante risks in the two farming activities, the optimal choice is to reduce the labor inputs into both of the farming activities and to engage more in the risk-free activity.

Proposition 3. *If there is a minimum level of L_2, $\widetilde{L_2}$, and $L_2^* < \widetilde{L_2} < \Omega$, labor cannot be optimally allocated.*
Let $\widetilde{L_2}$ be the minimum amount of labor inputs to be used for subsistence farming which ensures that the household is self-sufficient in food. Assume that $\widetilde{L_2} > L_2^*$.
If $-1 \leq \rho \leq \frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2\widetilde{L_2}(1-\kappa)^2}$,

$$L_1^* = \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2}$$

$$L_2 = \widetilde{L_2}$$

$$H^* = \Omega - \widetilde{L_2} - \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2}$$

If $\frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2\widetilde{L_2}(1-\kappa)^2} \leq \rho \leq 1$,

$$L_1^* = 0$$
$$L_2 = \widetilde{L_2}$$
$$H^* = \Omega - \widetilde{L_2}$$

If $\widetilde{L_2} \geq \Omega$, *then:*

$$L_1 = 0$$
$$L_2 = \Omega$$
$$H = 0$$

Proof. See Appendix C.2.2 ■

Proposition 3 demonstrates that a farming household may not be able to adhere to the optimal choice of labor allocation when they are food insecure. Conflict negatively affects food security, and a farmer thus has to allocate a certain level of labor to subsistence farming to be self-sufficient in food. If the minimum level of labor required to cultivate a subsistence crop is larger than the available labor, the farmer is unable to diversify. In Burundi, continuous episodes of conflict events have exacerbated the food insecurity problem that majority of farmers face on a daily basis. Provided that more than 50% of the population is chronically food insecure, farmers on the verge of food insecurity would resort to allocating more labor towards safer food crops.

Proposition 4. *A farmer with low* Ω *is more likely to fail to diversify her income sources. Let* Ω_H *be the high level of labor endowment, and* Ω_L *low level of endowment of two households. Even when* $L_2^* < \widetilde{L_2}$, *the household with* Ω_H *is likely to diversify its income sources. On the contrary, the choices of the household with* Ω_L *are restricted.*

As $\widetilde{L_2} << \Omega_H$, *the labor allocation of the household with* Ω_H *would be as below.*

If $-1 \leq \rho \leq \frac{\mu_1 - w}{\gamma\sigma^2 \widetilde{L_2}}$,

$$L_1^* = \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2}$$

$$L_2 = \widetilde{L_2}$$

$$H^* = \Omega_H - \widetilde{L_2} - \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2}$$

As $\Omega_L \leq \widetilde{L_2}$*, the labor the allocation of labor for the household with* Ω_L *would be the following.*

$$L_1 = 0$$

$$L_2 = \Omega_L$$

$$H = 0$$

Proposition 4 shows that the initial endowment of labor of a household affects its choices of diversification. Households affected by intense conflicts tend to experience changes in their composition as a result of loss or injuries of family members, recruitment of fighters, and forced displacement or migration of people for livelihood. In particular, poor and small scale farmers who use family labor intensively are more likely to be left with little choice and fail to diversify their livelihood portfolio.

3.4 Heterogeneity in Impacts of Conflict

Proposition 5. *Exposure to more intense violence, higher C, reduces the expected utility of a farmer,* $\mathbb{E}(u)$*, through production risk and food insecurity problem. However, this negative effect is mitigated by additional assets owned by the farmer.*

The expected utility of the farmer change according to the changes in the parameters.

$$\frac{\partial E(u)}{\partial \sigma} < 0 \qquad \frac{\partial E(u)}{\partial \widetilde{L_2}} < 0 \qquad \frac{\partial E(u)}{\partial \Omega} > 0$$

Suppose

$$\frac{d\sigma(C)}{dC} > 0 \qquad \frac{d\mathbb{1}(\widetilde{L_2}(C))}{dC} > 0$$

16

Applying the Envelope Theorem, we get

$$\frac{\partial \mathbb{E}(u)}{\partial C} < 0$$

Suppose that a household has an additional income sources, S, which contributes its consumption, $c = y_1 + y_2 + wH + S$. Addition of S does not change the optimal allocation, L_1^*, L_2^*, and H^*, with the given endowment, but the expected utility depends on the level of S. A farmer with larger S enjoys higher level of welfare when other factors remain constant. Whether the farmer diversifies farming activities or not, the marginal effect of exposure to violence is mitigated by the level of S.

$$\frac{\partial^2 E(u)}{\partial C \partial S} > 0$$

Proof. See Appendix C.3.1. ■

Proposition 5 states that the marginal expected utility of a farmer decreases as the conflict intensity increases through different channels shown in the proposition 2, 3, and 4. However, assets of a household compensates for the negative effects of exposure to violence on welfare. The additional income sources include interest from assets, livestock, or capital income such as remittance from abroad.

16 where $\mathbb{1}(\widetilde{L_2}(C))$ is an indicator function

$$\mathbb{1}(\widetilde{L_2}(C)) = \begin{cases} 1, & \text{if} \quad \widetilde{L_2} > L_2^* \\ 0, & \text{if} \quad \widetilde{L_2} \leq L_2^* \end{cases}$$

4 Data

4.1 Household Survey

We merge a household survey data with a conflict event dataset. The household data is the Enquete Nationale Agricole du Burundi (ENAB), a nationally represented household survey on agricultural activities at plot level for 2011-2012 collected by the Burundi National Institute of Statistics and Economics(ISTEEBU). The household survey provides detailed information on agricultural activities, and well-being status of households in rural Burundi. The data follow plots over two seasons (A, B).[17] There are 21,624 plots grouped into 12,035 fields owned by 2,622 households in 338 villages (Colline) belonging to 118 communities (Commune) in 16 provinces.[18] On average, 7.75 households are sampled per village. The survey contains several modules on plot characteristics (type, location, topography, land characteristics, and information on plot managers), household characteristics (information on household head and members, and living conditions), income generating activities (production inputs, cultivation of crops and other commodities, and non-agricultural activities), production technologies (equipment and fertilizer use), and consumption (food and nonfood expenditure).
Table 4 displays the summary statistics for the sampled households. The size of all farms owned by a household is on average 0.33 hectares. A household on average has 8.26 plots and grows 4.8 types of crops.[19] The average age of household heads is 43.63 years. 80% of households are led by a male head. 64% of household heads are literate, and 77% of them are married. A rural household on average spends 64,912 BIF for 15 days, and 65% of the expenditure is spent on food.[20] 46% of the sampled households have economic activities outside of the agricultural sector.

The summary statistics of plot characteristics are presented in Table 5. The average plot size is exceedingly small with 0.04 hectares. 78% of the sampled plots are supervised by a female

[17] A season: sawing in September-October, growing in November-December, harvesting in January; B season: sawing in February-March, growing in April-May, harvesting in June-July

[18] Following the modification of administrative division of the country in 2005, Burundi has 17 provinces, 129 communes, and 2,910 collines. (Central Bureau of Census (2008) *Burundi Population and Housing Census 2008*)

[19] The crops in consideration are 16 main crops: maize, rice, sorghum, bush bean, climbing bean, green bean(pea), beer banana, cooking banana, banana fruit, bitter cassava, soft cassava, sweet potato, potato, groundnut, soybean, and coffee.

[20] 64,912 BIF is roughly equivalent to 53 USD with the exchange rate of 1USD = 1230 BIF

manager. The average age of the plot managers is 41 years, and 60% of the plots are managed by a literate person. Crop mixing is a norm in farming practices in Burundi as a majority of the plots are used for cultivating more than 2 types of crops. In 96% of the plots, only crops are cultivated without other value added commodities such as vegetables and fruit. The average number of labor into a plot is 10.[21] The average value of crop production in a plot for the two seasons is 73 USD. The majority of the plots (92%) are used for collective production.

4.2 Data on Conflict Events

We use the leading conflict event datasets to measure the intensity of violent conflicts: the Armed Conflict Location and Event Database (ACLED) for Africa (Raleigh et al., 2010) and UCDP/PRIO Armed Conflict Dataset of the department of Peace and Conflict Research, Uppsala University and the Centre for the Study of Civil War at the Peace Research Institute Oslo (Gleditsch et al., 2002). The main conflict dataset, ACLED, provides historical information on all reported events of political violence covering all countries in the African continent for the period between 1997 and 2014. The dataset contains specific information on the date, location (latitude and longitude), actor, interaction type, event type, reported fatalities, and contextual notes. It covers all types of conflicts including lower levels of violent activities such as violence within and outside the context of a civil war, violence against civilians, rioting, militia interaction, and communal conflict. We trim the observations on the local violence within the territory of Burundi for 1997-2010.[22] Table 7 shows the fatalities aggregated by year recorded as a result of violence across the country in the two conflict datasets ACLED and UCDP-PRIO. The intensity of violence was high until 2005 and diminished afterwords.

In this paper, the GPS information of conflict events is at the core of the strategy to identify

21 The sample includes 3,375 plots with positive production but with labor input missing. For those plots, we impute the missing data using the average labor input per unit land for the corresponding household. We include 694 plots with no production output but with positive labor input, but exclude 2,828 plots with no production and with no labor inputs in the sample.

22 In the UCDP/PRIO Armed Conflict Dataset, conflict is defined as a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, and results in at least 25 battle-related deaths. The dataset provides political violence for the period of 1993-2015. We again limit the observations for Burundi and for the period of 1997-2010. However, in the dataset updated in February 2019, there is no record of the two years 2009-2010 for Burundi. Although the information is missing, the variations that come from the last two years should be minimal. The two datasets have their advantages and disadvantages, but the main difference of the two datasets is in the definition of conflict events. While ACLED is useful for the information on non-violent events, UCDP/PRIO only coded violent events (Eck, 2012).

the variations in the conflict intensity at plot level. The data are aggregated by conflict sites defined by a combination of latitude and longitude. All conflict sites are paired with each plot to calculate the distances from the sites to the locations of the plots. The main explanatory variable is the conflict intensity defined as the degree of violence at plot level.[23] The indicator captures the continued violence of various forms and sizes that took place nationwide for the study period between 1997 and 2010 in Burundi. We measure the conflict intensity at plot level by matching each plot with nearby conflict events based on two factors - degree of violence and spatial variations. The degree of violence is represented by deaths toll reported in each conflict site. An equal weight is given to deaths regardless of whether they stem from civilian or military actors, or from a conquering or defeated party. The spatial variations come from the distance calculated with geographical locations of plots and conflict events. Depending on how many fatalities were incurred in conflict events, how far from plots, farmers may experience different degrees of violence.

The conflict intensity at a plot is the cumulative fatalities from all conflict sites within a radius of 20 *km* from the location of the plot weighted by the distance for the period of 1997-2010.[24]

$$C_p = \sum_r Fatalities_r / Distance_{pr}$$

where r is a subscript for a conflict site matched with s a plot p. The conflict intensity is also separately calculated for two separate periods, 1997-2005 and 2006-2010, to distinguish the long term from short term impacts. Table 8 shows the summary of the conflict intensity indicator (weighted) based on fatalities and number of conflict events in the ACLED data for Burundi for the period of 1997-2010. Provided that each conflict site on average had 10 events, and the average number of fatalities was 71 deaths compared to the maximum values of 6,466 events and 1,641 deaths respectively, some areas experienced extremely massive violence than others did.[25]

23 The indicator of the conflict intensity is measured at plot level as the dataset provides the GPS information of plots. For households, we use the average conflict intensity of all plots owned by a households.

24 We take a radius of 20km because it is the distance that roughly covers 95% of conflict events within a province. However, it does not mean that conflict events are restricted within province. Regardless of the administrative division of the provinces where conflict events take place, we include any conflict event within 20 *km* from the location of a plot.

25 In the ACLED data, more than one third (246 out of 632 sites) of the conflict sites are reported to have zero casualty. The first quartile point of the indicator based on fatalities is 0 and third quartile is 5.

4.3 Data on Precipitation

Rainfall is one of idiosyncratic shocks and the main determinant of productivity and production decisions.[26] In many Sub-Saharan countries whose agriculture depends heavily on rain-fed production, low agricultural productivity and a high degree of income uncertainty are often attributed to rainfall shocks (Hansen et al., 2011; Townsend, 1995; Maccini and Yang, 2009).

We use the rainfall information obtained from Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), the rainfall estimates produced by the Climate Hazards Group, at the University of California, Santa Barbara.[27] The dataset contains the rainfall data with the latitude between 50S and 50N and all longitudes for the period of 1981-2018. The advantage of this dataset is that it incorporates high resolution - 0.05 degree resolution satellite imagery with in-situ station data to create rainfall time series for trend analysis. The information is collected at the second administrative level (Commune level). Rainfall is calculated as the monthly rainfall for twelve months in 2011 measured in *mm*. Rainfall shock in year 2011 is defined as the rainfall range more than two standard deviations away from the long term average rainfall of the previous decade (2001-2010) at the community (Commune) level.

4.4 Crop Portfolio

4.4.1 Type of Crop

In Burundi, the major food crops are maize, rice, beans, banana, sweet potato, cassava, potato, sorghum, groundnut, and peas, which provide food and income supply to rural households, and the main cash crop is coffee.[28] We categorize crops into two groups according to the degrees of risk in production: risky crops and safer crops. Risky crops are maize, rice, banana, coffee, soybean(soja), sorghum, and safer crops include cassava, bean, pea(green bean), potato, sweet potato, and groundnut.

[26] Rainfall is the direct input of agricultural production, which may lead to crop failure, and thus affects farming decisions.

[27] http://chg.geog.ucsb.edu/data/chirps/

[28] Top 3 commodities are cassava, banana, and sweet potato in terms of production quantity, and banana, cassava, and dry bean in terms of production value in 2012 (Food and Organization, 2014). In the sample, the most preferred crop in 2011-2012 is maize, which was cultivated in 34.5% of the plots, followed by cassava, bean, sweet potato, and banana. Coffee is the main cash crop but only 7.56% of the sampled households cultivated coffee.

We apply two criteria to categorize crops. The first criterion is the conventional conception from the existing evidence. Traditionally, safer crops are defined as crops whose harvest can be delayed or difficult to root during periods of insecurity like root crops (cassava, sweet potato, and potato), and crops that require little maintenance like seasonal crops (green pea). On the other hand, risky crops are lucrative/cash crops, and crops that are easy to root, require a lot of attention (maize), and need intensive cultivation like perennial crops (banana) (Rockmore, 2012). Conventionally, maize and beer bananas are considered risky crops, while cassava and potato are safer crops in Burundi.[29] In neighboring Rwanda, it is noted that farmers hedged risk by expanding the production of taro and cassava which are resistant against drought and flood (Verpoorten, 2009). In Tanzania, sweet potato is considered less risky with its resistance to risk factors (Dercon, 2018). Coffee is considered risky crops as it is the main cash crop in Burundi, and coffee trees were particularly targeted for burning by the rebel because the export of coffee is the main source of revenue to the Burundian government (Human Right Watch report, 1998).

The second criterion to decide a type of crops is price and production risk. We calculate the variances and covariances of the producer prices and production values of main crops over two decades between 1991 and 2010 in Burundi.[30] Bundervoet (2009) demonstrates that prices of agricultural commodities in rural Burundi were similar across provinces in 1998-1999. We, therefore, use the national producer price with the assumption that the prices of crops did not vary much across subnational divisions.[31] One exception is the high variance of the price due to the drastic increase in the price toward the end year. This exceptional cases are bean and groundnut. For example, the producer price of beans doubled over a decade from 513.3 USD per kg in 2000 and 1,084 USD per kg in 2010, which was the highest rise among the main crops cultivated in Burundi (source: FAOSTAT). An increase in cultivation of bean would be rather interpreted as a response to the sharp rise in the price of the commodity.

[29] Bundervoet (2010) uses cassava cultivation as a proxy for investment in low-risk crops and maize cultivation as a proxy for risky crops. Cassava is considered to be a low-risk crop because it strongly resists to droughts and flood, and sustains regardless of soil quality. It is safer in that its root can be kept under soil and harvested when needs arise. Cassava is also an important subsistence crop. In contrast, maize, though providing higher returns, requires more subtle conditions for cultivation in terms of rainfall and soil quality. He argues that there was a decrease in the real price of cassava and an increase in the real price of maize during the 1993-98 period.

[30] We obtain information on prices and production values of maize, banana, bean, cassava, potato, rice, sweet potato, coffee, groundnut, pea, and soja from FAOSTAT. The other crops follow the conventional classification.

[31] The domestic producer price of coffee was fixed by the government.

4.4.2 Crop diversification

The crop diversification index is measured based on *Herfindahl-Hirschman index*.[32] As a high *Herfindahl-Hirschman index* means low degree of crop diversification, we obtain a crop diversification index by subtracting the *Herfindahl-Hirschman index* from unity. The crop diversification index thus ranges between 0 and 1 with 0 being for cultivation of one crop on the plot.

$$HHindex_p = \sum_i \left(\frac{\text{Value of crop } i}{\text{Total crop value on plot } p}\right)^2$$

$$cropdiv_p = 1 - HHindex_p$$

Figure 5 shows the distribution of the index of crop diversification. 37% of the sampled plots in consideration is monocultural.

5 Empirics

5.1 Identification Strategy

The identification strategy exploits the variations of conflict intensity determined by fatalities and locations of conflict events, and the related variations in agricultural activities. The conflict intensity in Burundi is considered as exogenous. Although the country's conflict is characterised as fighting between the two ethnic groups - Hutu and Tutsi, Uvin (1999) argues that the political system of Burundi is based on fear and suppression.[33] In most of the civil wars which occurred after the outbreak of violence in 1993, the Burundian army was not able to identify people's ethnicity. The violence was indiscriminate on civilians, and most of the victims were civilians regardless of their ethnicity (Human Rights Watch, 1998). This suggests that violence itself was near-exogenous regardless of regional or individual characteristics. To

[32] There are several measures of crop diversification (Herfindahl Index, Ogive Index, Entropy Index, Modified Entropy Index and Composite Entropy Index) being used in a number of agro-economic literature (Shiyani and Pandya, 1998; Gupta and Tewari, 1985). *Herfindahl-Hirschman index* is the concept that indicates the degree of competitiveness in the market widely applied in competition law, and technology management, which is a measure of a size of firms in relation to the industry.

[33] Attacks by Hutu militia became "increasingly brutal and random, affecting all of the country and causing profound fear among Tutsi as well as Hutu bystanders" (Uvin, 1999).

demonstrate the exogeneity of the Burundian conflict, Voors et al.(2012) test whether exposure to violence is associated with community characteristics. The results ascertain that there was no selection into violence as socio-economic characteristics of household and community (literacy, age, gender of household head, status of breeding, ethnicity, consumption, cultural aspects, and agricultural activities) do not explain the pattern of violence during the period between 1993 and 2003 in Burundi.

The specification of the econometric model for the analysis at plot level is the following.

$$y_{rhp} = C_{rhp}\beta + X'_{rhp}\alpha + Z'_{rh}\gamma + \phi_r + u_{rhp}, \tag{2}$$

where y_{rhp} is the outcome variable for plot p of household h in province r, C_{rhp} is the indicator of conflict intensity introduced in Section 4.2, X_{rhp} is plot characteristics, and Z_{rh} is household characteristics. To reduce unobserved heterogeneity, we add a rich set of plot level information on area of plot[34], topography, location, anti-erosion, type of plot[35], altitude, farming technology[36], ratio of the production of non crop commodities - vegetables and fruits, characteristics of plot managerWe impute the missing values of age of plot manager by replacing it with the mean of the variable across individual plots., and accessibility to market (distance to the nearest cities[37]).

For the analysis at the household level, the specification is as follows.

$$y_{rh} = C_{rh}\beta + Z'_{rh}\alpha + \phi_r + u_{rh}, \tag{3}$$

where Z_{rh} in equations (2) and (3) represent household level covariates. These include information concerning characteristics of a household head (gender, age, literacy, and marital status), wealth status, and economic opportunities (distance to the regional capital). The distance to the regional capital proxies for transportation costs, accessibility to infrastructure (road and market), and general information access. The wealth of the household is measured with the

[34] The area of plot is predetermined.

[35] The type of plot is whether the plot is private or collective.

[36] We include a type of farming equipment as a covariate. Since the technological level of Burundian Agriculture is low even for cash crops, crop specific advancement in farming is not expected.

[37] We calculate the distance to one of the big cities in Burundi. 32 cities are selected as a proxy for local markets. The main cities are Bubanza, Buhongo, Bukirasazi, Bururi, Cankuzo, Cibitoke, Gitega, Kabezi, Karuzi, Kayanza, Kayero, Kayogoro, Kibondo, Kirundo, Kigozi, Makamba, Magara, Mukenke, Muramvya, Murore, Musenyi, Muyaga, Muyinga, Mwaro, Ngozi, Nyanza-Lac, Rugari, Rumonge, Rutana, Ruyigi, Zanandore

land area per adult owned by the household.[38] For all specifications, we add information of whether the household managed to get credit for the past 3 years as a covariate. I also add a rainfall shock as an exogenous variable that affects farming decisions.

As the analysis is done at plot or household levels, it would be ideal to estimate the conflict effect using within village variations in order to alleviate heterogeneity in farming decisions at the village level. However, village fixed effects will remove the necessary variations in the measure of the conflict intensity because violence is a collective shock that affects a whole community. For this reason, we exploit within-province variations by using province fixed effect, ϕ_r. The fixed effect controls for population density, agroecological conditions and other province invariant characteristics that might be correlated with the conflict intensity.

5.2 Empirical Results in Farming Decision

5.2.1 Consequences of Conflict

Exposure to intense violence has persistent impacts on the economic status of households through loss of household members, destruction of assets and livelihoods, and disruption to markets and production activities. Since violent conflicts impose challenges different from other shocks, coping strategies of rural farmers may differ from their behaviors in response to other idiosyncratic shocks in peace time. Decisions of farmers are presumably determined by the relative prominence of the underlying risks. We look at how the two elements - production risk and food insecurity problem respond to conflict.

Conflict poses systematic risks to the livelihood and welfare of individuals and households. Table 9 presents production risk measured with the variance and covariance in the production of the two types of crops. We separate the period into three: pre-conflict (1991-1992), conflict (1993-2005), and post-conflict periods (2006-2011). The production of the two types of crops were highly correlated before the eruption of the harsh conflict in the pre-conflict period. However, under intense violence, production risk increased, but the correlation of the production became negative. In the aftermath of severe conflict, the covariate risk recovered to the pre-conflict level, while the production risk remained high.

[38] Land is the main assets in rural Burundi. Ownership of assets are correlated with social status of households (Oseni and Winters, 2009).

Conflict exacerbates the existing constraints faced by farmers and seriously threatens food security of rural households. About 1.5 million people are estimated to be severely food insecure in Burundi in 2017.[39] The literature suggests that high food prices have negative effect on food security of poor households (Grace et al., 2014). Figure 6 presents the fluctuation of crop prices as deviation from the 1991 price between 1990s and 2000s. The crop prices saw a huge fluctuation since 1993. During the intense civil wars, even the prices of safer crops sharply increased. Substantial risk in crop production leads to variations in prices in agricultural commodities, and high food price would matter more seriously for poor households.

5.2.2 Evidence on Subsistence Farming

Implication 1: *Burundian farmers tend to diversify crop portfolio if it is feasible, and allocate more labor to cultivation of safer crops.*

As shown in the section 3.2, when multi-cropping is feasible, a risk averse farmer would prefer crop diversification, and allocates more labor to safer crops than to risky crops. The data confirm that on average, 64% of the crop production comes from cultivating safer crops in the sampled plots as shown in Table 10. Among the monocultural plots, 65% of them are used to cultivate safer crops.

5.2.3 Crop Diversification

Implication 2: *Intense conflict induces a farmer to fail to diversify crop portfolio in a plot.*

Empirical results in Table 11 suggests that exposure to long term violence has negative effects on crop diversification. Column 1 shows that a farmer exposed to higher degrees of the conflict intensity is more likely to fail to mix crops. In column 2, we compare the short and long term effects of conflict using the two separate periods of 1997-2005 and 2006-2010, and find that the long term adaptation takes place towards less diversification. In column 3, we look at the impacts of conflict for the two different groups - poor and non-poor groups. The poor group is defined as households which spend less than the poverty line (1.9$ per day per person),

[39] The food insecurity was more severe especially in Kirundo, Muyinga, Rutana, and Ruyigi provinces(FAO, 2017 *Crop Prospects and Food Situation*.

serving as a proxy for the households facing food insecurity problem. The negative effect of the conflict intensity is larger for the poor group than for the non-poor group. In column 4, we restrict the sample to the upper half of the poor group and the lower half of the non-poor group to see the difference in the impacts for the households around the poverty line.[40] The disparity in the negative effect of conflict is even greater between the two subgroups.

[Table 11 is here]

We extend the third and fourth columns to conduct chow tests for the two groups. In Table 12, the test results confirm that the responses of the two groups towards crop diversification systematically differ from each other.

5.2.4 Income Diversification

Implication 3: *The probability of participating in activities outside agriculture is increasing in response to violence due to an increase in production risk. However, the decision may alter as food insecurity and a change in household composition have confounding effects.*

We investigate whether households exposed to more fierce violence are more likely to engage in activities outside of the agricultural sector to mitigate the risk of income variability. The dependent variable is a dummy of participation in non-agricultural activities. Non-agricultural activities include wage work outside of the agricultural sector, and self-employment in commercial or artisan work (Adjognon et al., 2017). I use a Linear Probability Model(LMP) instead of a nonlinear model because LPM is less costly in terms of computation to cluster the standard errors at spatial unit. The conflict intensity indicator is aggregated at household level. We add a dummy of participation in off-farm activities (forestry, breeding, fishing, beekeeping, fruit picking) as a covariate. Table 13 shows that the coefficient is positive as expected, but statistically insignificant in the column (1). When comparing the two periods in the column (2), while farmers affected by higher degrees of the conflict intensity increases participation in non-agricultural activities in the long run, more intense violence discourages farmers from diversifying their sources of income in the short run. A decrease in labor availability is expected to be

[40] The sample size is 996 households, out of which 809 households are in the poor group and 187 are non-poor households.

more dominant in the short run, leading to reduction in participation in the non-agricultural activity. On the other hand, an increase in production risk would encourage farmers to diversify income in the long run. The coefficients are not statistically significant because Food insecurity and changes in return to the activity can confounds the effects. In column (3) and (4), we compare the households in the two groups. Households in the non-poor group manage to diversify their income sources, whereas those in the poor group do not successfully adopt a diversification strategy.

[Table 13 is here]

5.2.5 Welfare Effect

Implication 4: *Exposure to intense violence reduces the welfare of the affected farmers. However, the negative effect of conflict is disproportionate according to farmers' assets.*

We examine the impact of conflict on welfare of households. To assess the heterogeneity effects by the wealth status of households, we use an interaction term between the conflict intensity and the assets that households own.[41] Table 15 presents the results of estimation of the impacts of conflict on the welfare of households. The consumption is the amount of total expenditure of a household including both food and nonfood consumption per adult for 15 days measured in Burundian Franc (BIF).[42] The results are in line with the existing evidence that civil conflicts reduces consumption in the short run. Verwimp and Bundervoet (2009) find that exposure to higher level of violence reduces consumption growth of household in Burundi.[43] The positive and statistically significant coefficient on the interaction term in column (1) suggests that the wealthier farmers are less affected by violence. This mitigating effect is solidified over time as the coefficient of the long-term effect of the conflict intensity is positive and statistically significant at 10% significance level, while the short-term effect is negative and insignificant in

41 Rockmore (2011) find that the impacts of risk of violence on consumption levels disappears once allocation of asset portfolio is controlled.

42 The welfare indicators often used in the literature are income, consumption, and assets. As the data do not provide information on income, we measure welfare using the household consumption.

43 The literature provides competing evidence on the long term effect of conflict on consumption. Serneels and Verpoorten (2015) find that households that experienced more intense conflict are lagging behind in terms of consumption six years after the conflict, while Bellows and Miguel (2009) find no persistent adverse effects of civil wars on consumption level in Sierra Leone.

the second column. While owning more assets is not helpful for non-poor group, farmers with larger land are less affected by this negative effect of conflict in the poor group. This demonstrates that the role of asset in farmers' welfare is more important for the population who live under poverty line in Burundi. The chow test confirms the systematic difference between the two groups. The failure of diversifying crop portfolio can be one of the channels through which the welfare of the war-vulnerable households declines.[44] Poor farmers who have more incentive to diversify but fail to do it due to constraints, which is welfare-diminishing.

[Table 15 is here]

5.2.6 Empirical Evidence of Adaptation

In the conflict literature, it is widely accepted that violence has persistent effects on the behaviors of individuals. In the estimations of the diversification strategies for the two separate periods, the cumulative effect from exposure to the early and more intense violence dominates and lingers for many years, and the short-term response is in the opposite direction. The change in the sign of the coefficients, on one hand, reflects the alteration in the dominant risk factors that determine the behavior of farmers, and, on the other hand, indicates that farmers adapt to the protracted conflict over time. This is in accordance with the finding of the previous studies that households remain entrenched in the strategies adopted during war-time after the end of the conflict (Bozzoli and Brück, 2009; Arias et al., 2018).[45]

6 Robustness

The regression outcomes for effects of conflict on economic and agricultural activities are in accordance with the theoretical predictions. I conduct several robustness check to confirm the consistency of the results. To take care of the potential endogeneity of the conflict intensity indicator, we will use an instrument variable approach using external (Two Stage Least Square estimation) and internal (Lewbel Estimator, (Lewbel, 2012)) instruments.

[44] In the study of Malawi, Mango et al. (2018) show that crop diversification has a positive and significant effect on the household consumption.

[45] In the study of northern Mozambique, Bozzoli and Brück (2009) find that households follow the agricultural practices that they adopted as war-time coping strategies even three years after the end of the conflict. Arias et al. (2018) show that households learn to change their behaviors to adopt the low risk strategies after exposed to long lasting low or medium intensity conflicts.

6.1 Potential Endogeneity of Conflict Intensity

The challenge by which the conflict literature has been often impeded is the endogeneity of violence. In the study on the dual-causal relationship between armed conflict and household welfare, [46] Economic outcomes and agricultural choices may be systematically correlated with location specific factors associated with agroecological, cultural, historical, and other spatial attributes which may impact the conflict intensity at the same time. If the conflict intensity is not orthogonal to the error term, the OLS estimator would be biased. The exogeneity assumption of violence can be violated for the two following reasons in the analysis in this paper.

Omitted Variables Occurrence of violence may not be random. Unobserved factors could affect both the incidence of violence, and farming decisionss. The source of bias is mostly expected to come from regional characteristics as government and rebel forces are likely to confront each other over regions of tactical importance or of high levels of development.[47] Evidence suggests that the community characteristics associated with geography, ethnic composition, economic opportunities, level of assets to be taxed, social tension from inequality, and level of human capital development can influence the propensity of violence taking place around (Deininger, 2003; Arcand and Wouabe, 2009; Rockmore, 2011). In Burundi, the provinces severely affected by the civil wars such as Bubanza, Bujumbura rural, and Cibitoke were the richest before the eruption of the violence. Households in those provinces had higher level of assets represented by livestock holding than in other provinces (Bundervoet et al., 2009). The initial conditions including social and economic factors (land scarcity and income inequality among farmers) intertwined with the livelihood choices of households can be determinants of exposure to violence.

Measurement Errors There can be a systematic measurement errors in the indicator of conflict intensity. This shortcoming is derived from the nature of the conflict data.[48] News reports on which the conflict data are based may be biased because the reported death tolls represent

[46] Justino (2009) argues that endogeneity that comes from household behaviors makes the political shocks different from other exogenous shocks.

[47] Hagelstein et al. (2008), in the study of the Algerian civil war, find that level of violence were higher in wealthier areas.

[48] Different conflict datasets have their own limitations and problems on a number of grounds.

only a fraction of victimization as indirect deaths are not accurately measured. It is thus highly likely that the conflict event data have measurement errors due to differing degrees of coverage of some regions or certain forms of violence.[49] The ACLED dataset includes conflict events that are not recorded in other datasets as the threshold for inclusion is lower than other conflict datasets. Additionally, the estimated fatalities are usually the lowest number of fatalities reported from several sources. Another factors that might cause an measurement error is the incorrect measurement of plot location. The survey uses GPS devices, which is considered an effective tool. However, it is not completely free from errors because of factors depending on enumerators. In fact, some of the plots in the survey have wrong GPS information.

6.2 Solution for Endogeneity

The potential endogeneity problem of the conflict intensity is addressed by approaches using external and internal instruments variables, IV and Lewbel estimation (Lewbel, 2012). We first use geographical information as an exclusion restriction to take the exogenous portion of variations from the conflict intensity. The three instrument variables are the distance to Bujumbura, distance to Mpanda, and distance to the nearest border.[50] The distance to Bujumbura is a valid instrument based on Buhaug and Rød (2006). They demonstrate that territorial conflict is more likely to occur in remote and sparsely populated regions while governmental conflict occurs predominantly in densely populated areas near capitals. The Burundian civil wars are classified as governmental conflict in which rebel groups fought over the state control. Violence was therefore more intense and concentrated near the former capital, Bujumbura.[51] The distance to Mpanda exogenous explains the conflict intensity as the spread of violence is related to the geographical distance from the headquarters of rebel groups (Arcand and Wouabe, 2009).[52] During the Burundian civil wars, the major rebel groups had headquarters near the capital, and National Liberation Front (Front de Libération Nationale - FROLINA) was based in Mpanda,

49 The ACLED data contain only a subset of acts of violence and do not cover every village/community within a country (Rockmore, 2012).

50 The Geographical Information Data is obtained from GADM version 1.0 (March 2009). GADM is a geographic database of global administrative boundaries.(http://www.gadm.org)

51 Voors et al. (2012) suggest that the geographical indicator - distance to the capital - is correlated with experience of violence in Burundi.

52 Arcand and Wouabe (2009) also exploit geographical variations of the conflict intensity instrumented by the distance to the rebel headquarters to examine its impacts of the 27 years long Angolan civil war on child health, household expenditures, educational attainment, and fertility.

Tanzania. The distance to the border determines the conflict intensity because the rebel groups in Burundi are financed by external actors, diaspora, and neighboring countries.[53] The continued violence was motivated by strong smuggling networks in the whole region. Secondly, to address the problem of the measurement error in the conflict intensity, we can identify the parameters taking an advantage of the heteroskedastic nature of the conflict intensity, following the recent development of Lewbel (2012). Details of the Lewbel estimation are provided in the Appendix E. In estimation, we combine the two sets of instruments, external instruments and internal instruments based on heteroskedasticity.

Figure 7 and 8 are the coefficient plots to compare the estimation of OLS, IV, and combination of external and internal IVs for the impact of conflict on crop diversification and income diversification respectively. The estimation with external variables has longer confidence intervals, which in all specification include the confidence intervals of the OLS estimators. The coefficients in the estimations with both external and internal instruments are close to those in the OLS estimation. The results are consistent across the three different estimations without any significant deviation of the IV approach from the baseline estimation without correcting endogeneity.

6.3 Sensitivity Analysis

We conduct several sensitivity analyses with alternative measures of the conflict intensity. We first use the incidence of conflict measured with the weighted number of conflict events within 20 km from the location of a plot weighted by the distance between the plot and each conflict site, replacing the conflict intensity based on fatality. Second, we test with the conflict intensity measured with the total number of fatalities without a weight of the distance. We then use the conflict intensity with a smaller spatial coverage counting weighted fatalities of conflict sites within a radius of $10km$ instead of $20km$ from the location of plots. We lastly generate a conflict intensity indicator with the alternative data source, UCDP-PRIO conflict dataset. The results of the sensitivity tests confirm that the effect of conflict intensity on diversification are consistent. The results are reported in Table 19 in Appendix.

[53] Akresh and De Walque (2008) in their study on the impacts of conflicts on educational outcomes of different cohorts of Rwandan children use the distance to the Ugandan border as an exclusion restriction in order to identify the conflict intensity of the 1994 Rwandan genocide.

6.4 Discussion

6.4.1 Composition of Crop Portfolio

Implication 4 poses a question that poverty may ascribe to a composition of crop portfolio, not to a reduction in crop diversification. (Arias et al., 2019) show that under prolonged violence, farmers concentrate on subsistence activities that leads to low profitability. If farmers exposed to more intense conflicts decide to cultivate a larger proportion of low risk crops, the production of those crops unfortunately will generate less profit. This eventually leads to lower welfare of farmers. To answer this question, we estimate the impact of conflict on the changes in composition of crop portfolio. The dependent variable is the ratio of output values of safer crops to the total crop production on a plot. The results are presented in Table 21. The coefficient associated with the conflict intensity is negative and statistically insignificant. This suggests that farmers exposed to more intense violence allocate more resources toward risky crops than safer crops. When the two risky activities are not substantially different, a war-vulnerable farmers in the long run are likely to become risk-seeking. This finding is consistent with Voors et al. (2012) who show that exposure to violence changed the degree of risk-aversion of Burundian farmers towards risk-loving.

6.4.2 Conflict-Induced Migrants and Internally Displaced People

The first concern regards a selection bias due to possibility of nonrandom migration. Violent conflict is a driver of forced displacement (Brück et al., 2019). People living in regions with higher intensity of violence are more likely to have migrated or to have been displaced, and thus be missing in the sample. Omitting this aspect thus may cause under- or overestimation of the impacts of violent conflict on the outcomes. Although the data do not have information on migration status of farmers, surveys and reports on Burundian refugees states that the selective migration problem is unlikely to play a role in the analysis as we look at the relatively long term effects of violence. In Burundi, over 50 percent of the rural population had been displaced, but returned to their homes after conflicts ended in their regions (UNFPA, 2002). On average, the displacement duration is no longer than a year or three agricultural seasons (Verwimp and Van Bavel, 2014). A vast majority of the internally displaced persons had access to their land of origin(for the Coordination of Humanitarian Affairs, 2005).

7 Conclusion

Despite the recovery of economic growth after the fierce civil wars, there has been little progress in agricultural productivity, accompanied with the widespread poverty and food insecurity in Burundi. In order to design effective poverty-reduction policies, it is important to understand the consequences of conflict and their effects on the livelihood of the poor population in the fragile environment. This paper provides the theoretical and empirical evidence of how political risk shapes farming strategies of Burundian farmers. The theoretical model predicts that exposure to violence deteriorates the constraints faced by small scale farmers and precludes adoption of adequate strategies. Production risk and disruption on food security caused by conflict are the main drivers to determine responses of the farmers. Even though crop diversification is a welfare-increasing risk-mitigating strategy, farmers with limited assets would end up failing to diversify their crop portfolio.

To provide empirical evidence of the impacts of violent conflicts on behaviors of farming households, we use a rich plot level agronomic dataset and combine it with geo-referenced conflict data. By matching multiple conflict sites to a plot, we measure the cumulative conflict intensity to which a plot is exposed during the period between 1997 and 2010. With this spatially disaggregated measure of the conflict intensity, we estimate the impacts of the intensity of violence on farmers' decisions on crop and livelihood diversification. Contrary to the existing evidence that farmers resort to crop diversification to mitigate risks in developing countries, we find that Burundian farmers exposed to protracted conflict fail to adopt crop diversification even though it is an efficient farming strategy. The empirical finding is a prominent indication that nature of political shocks differ from other idiosyncratic or transitory shocks. Higher degrees of violence aggravate farmers' constraints during or in the aftermath of conflict, inducing deviation from the optimal choice. We probe the robustness of our findings by an instrumental variable approach to address the potential endogeneity problem in the conflict intensity.

The difference in the long term and short term impacts of conflict shows that predominant risk factors change and their effects depreciate over time. In the short run, direct destruction such as reduction in the size of household labor prevails whereas in the long run, the uncertainty in agricultural input and output markets and the consequential production risk dominates. Long-term adaptation towards a failure in adoption of an efficient strategy does not guarantee an improvement in welfare, and war-vulnerable farmers thus are easily pushed into a poverty trap. This sequence of decision making is problematic because poverty is self-reinforcing as it leads to chronic malnutrition which would consequently affect human capital and socio-economic outcomes.

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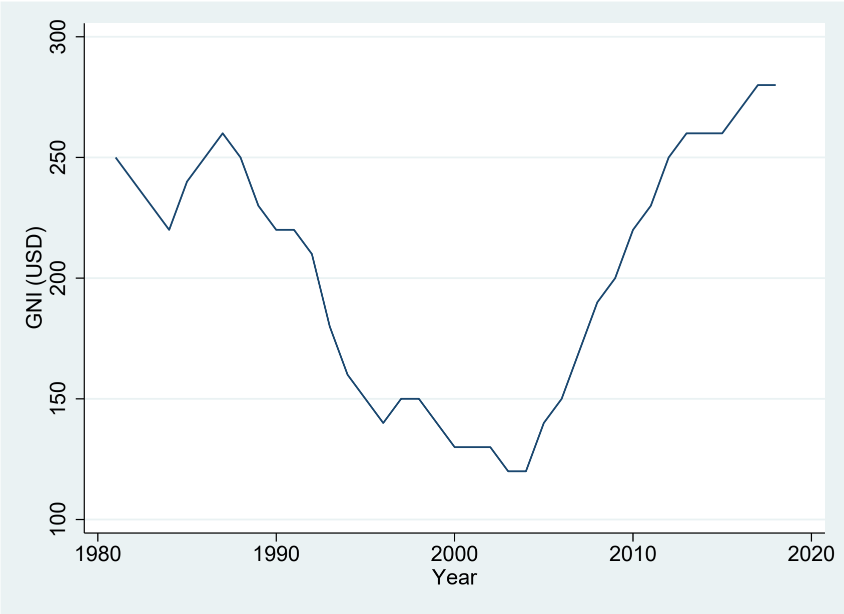
A Figures and Tables

A.1 Economic Performance of Burundi (1980-2010)

Figure 1: Per capita Income (Current USD)



Source: World Bank

A.2 Non-separability Test

Table 1: Separability Test

	Total Labor	Hired Labor	Aid Labor
	(1)	(2)	(3)
Number of Working members per hh	8.940**	2.126**	−2.885***
	(3.762)	(0.927)	(0.697)
Plot Area (hectare)	−1366.555***	−81.339***	−40.559***
	(75.524)	(11.242)	(6.116)
Observations	14472	15025	15025
R2	0.156	0.104	0.085
Plot characteristics	Y	Y	Y
Household characteristics	Y	Y	Y
Village FE	Y	Y	Y

† Total labor demand per hectare in plot
† Standard errors are clustered at household level. Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

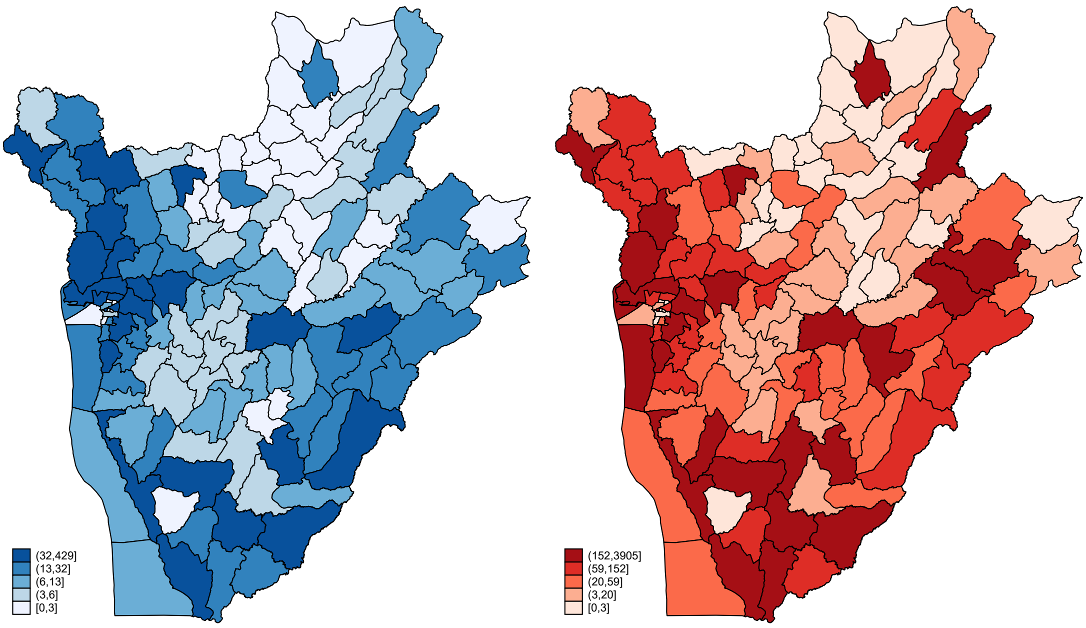
A.3 Farm Size in African countries

Table 2: Average Farm size in African countries

Country	Av. Farm Area	Country	Av. Farm Area
Ethiopia (2012)	0.78	Ghana (2013)	1.56
Kenya (2005)	0.53	Malawi (2011)	0.47
Niger (2011)	2.91	Tanzania (2013)	1.2
Uganda (2012)	0.97	Burundi	0.041

A.4 Conflict Intensity in Burundi (1997-2010)

Figure 2: Conflict Intensity at Commune



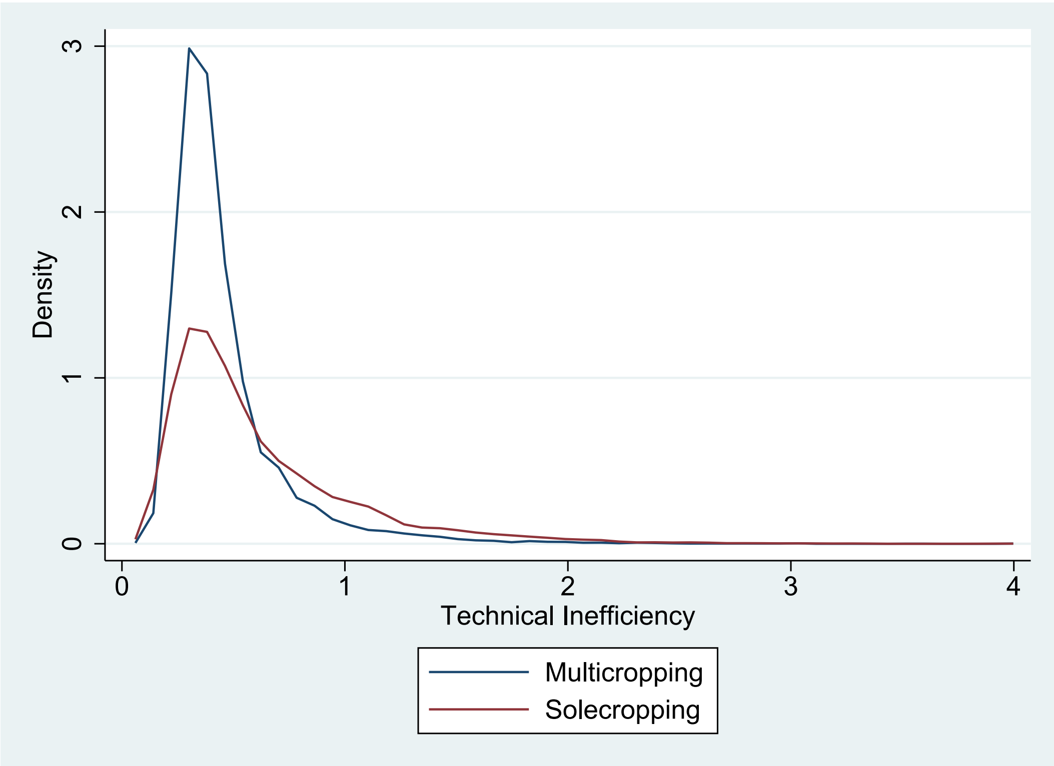
(a) Events (b) Fatalities

A.5 Technical Efficiency

Table 3: Estimated Technical Inefficiency by Number of Crops per Plot

Number of Crop	Number of Obs	Mean	s.d.
1	5,632	0.77	0.55
2	8,071	0.47	0.29
3	1,621	0.42	0.23
4 or more	372	0.37	0.15

Figure 3: Technical Inefficiency



Polyculture: N=10,058
Monoculture: N=5,638

A.6 Descriptive Statistics

Table 4: Summary Statistics of Households

	Observation	Mean	SD	Minimum	Maximum
Land Area (hectare)	2,490	0.33	0.32	0	3.21
Size of Household (persons)	2,344	5.20	2.47	1	20
Age of Head (years old)	2,386	43.63	15.56	16	99
Gender of Head (male=1)	2,434	0.80	0.40	0	1
Literacy of Head (literate=1)	2,434	0.64	0.50	0	1
Marital Status of Head (married=1)	2,436	0.77	0.42	0	1
Expenditure (BIF)	2,366	64,811	91,728	0	2,102,043
Expenditure on Food (BIF)	2,366	41,910	29,889	0	300,450
Expenditure per Adult (BIF)	2,326	25,915	43,547	0	1,051,021
Number of Plots	2,490	8.26	5.49	1	51
Number of Crops	2,490	4.79	2.15	0	13
Off-farm Activities (yes=1)	2,490	0.85	0.36	0	1
Non-Agricultural Activities (yes=1)	2,393	0.39	0.49	0	1
Revenue from Non-Agricultural (BIF)	2,490	445	3,670	0	162,620

**Source: ENAB 2011-2012*

Table 5: Summary of Plot

	mean	sd	min	max
Plot Area (hectares)	0.04	0.05	0	0.94
Total Labor	10.00	8.84	0.12	359
Production of Crops in Value (USD)	73	534	0	47294
Crops Only (=1)	0.96	0.20	0	1
Crop Diversification Index	0.25	0.22	0	0.79
Multiple Crops (=1)	0.79	0.41	0	1
Male Plot Manager (=1)	0.22	0.41	0	1
Literate Plot Manager (=1)	0.60	0.49	0	1
Age of Plot Manager	41	11	5	96
Risky Crops Production in Value	0.32	0.37	0	1
Riskless Crops Production in Value	0.64	0.39	0	1
Topography: On the top	0.16	0.37	0	1
Topography: Hillside	0.57	0.49	0	1
Topography: At the bottom of the hill	0.39	0.49	0	1
Anti-erosion: Terraces without hedges	0.78	0.41	0	1
Anti-erosion: Terraces with hedges	0.04	0.19	0	1
Anti-erosion: Ditches without hedges	0.05	0.23	0	1
Anti-erosion: Ditches with hedges	0.24	0.42	0	1
Location: Between dwellings	0.55	0.50	0	1
Location: Between dwellings	0.55	0.50	0	1
Location: In the bush with campsite	0.61	0.49	0	1
Location: In the bush without campsite	0.09	0.28	0	1
Collective (=1)	0.92	0.26	0	1
Distance to Nearest Market	14.68	8.45	0.26	79.46
Altitude(m)	1578	302	3	5117
Observations	17742			

ENAB 2011-2012

Table 6: Summary Statistics of Plot

	Observation	**Mean**	**SD**	**Minimum**	**Maximum**
Crop Production (Value)	20,570	63	496	0	47,294
Crop Diversification Index	17,050	0.26	0.22	0	0.79
Gender of plot manager (male=1)	18,357	0.22	0.41	0	1
Literacy of plot manager (literate=1)	20,202	0.59	0.49	0	1
Age of plot manager (married=1)	20,202	41	11	5	96
Altitude (*m*)	20,570	1,571	304	1	5,117
Plot Type (Collective=1)	18,357	0.92	0.27	0	1
Location: On top of hill (=1)	18,357	0.15	0.36	0	1
Location: Hillside (=1)	18,357	0.56	0.50	0	1
Location: At bottom of hill (=1)	18,357	0.39	0.49	0	1
Anti-Erosion: Terraces without hedges (=1)	18,357	0.78	0.41	0	1
Anti-Erosion: Terraces with hedges (=1)	18,357	0.04	0.19	0	1
Anti-Erosion: Ditches without hedges (=1)	18,357	0.053	0.22	0	1
Anti-Erosion: Ditches with hedges (=1)	18,357	0.22	0.42	0	1
Topography: Between dwellings (=1)	18,357	0.54	0.50	0	1
Topography: In the bush without a campsite (=1)	18,357	0.59	0.49	0	1
Topography: In the bush with a campsite (=1)	18,357	0.08	0.27	0	1

**Source: ENAB 2011-2012*

A.7 Conflict Data

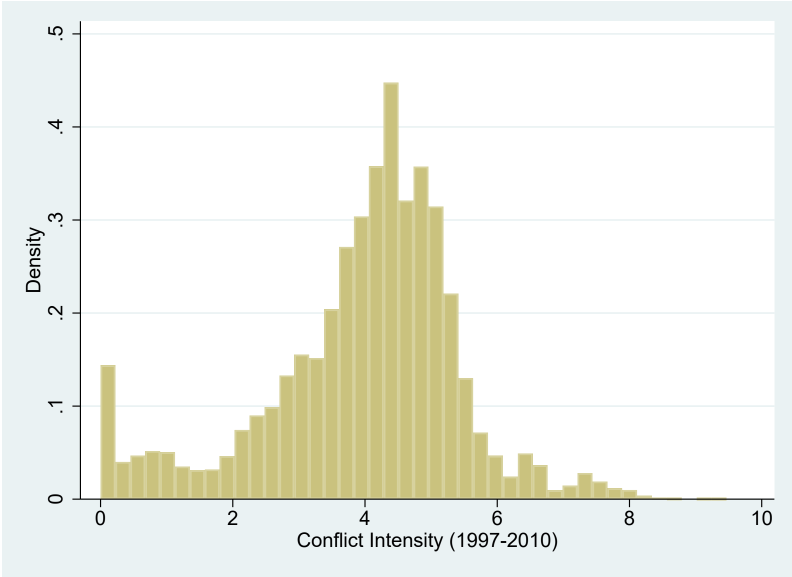
Table 7: Total Fatalities and Number of Events by Year

	Fatalities		Number of Event	
Year	ACLED	UCDP	ACLED	UCDP
1997	4274	835	218	53
1998	1280	935	118	46
1999	1728	749	165	57
2000	3893	1737	507	139
2001	3917	1183	632	99
2002	2131	1354	441	163
2003	1471	1101	216	102
2004	536	420	79	63
2005	586	312	75	70
2006	174	149	113	32
2007	61	8	29	6
2008	190	201	104	20
2009	73	NA	83	NA
2010	154	NA	102	NA

Table 8: Conflict Intensity at Plot (Weighted)

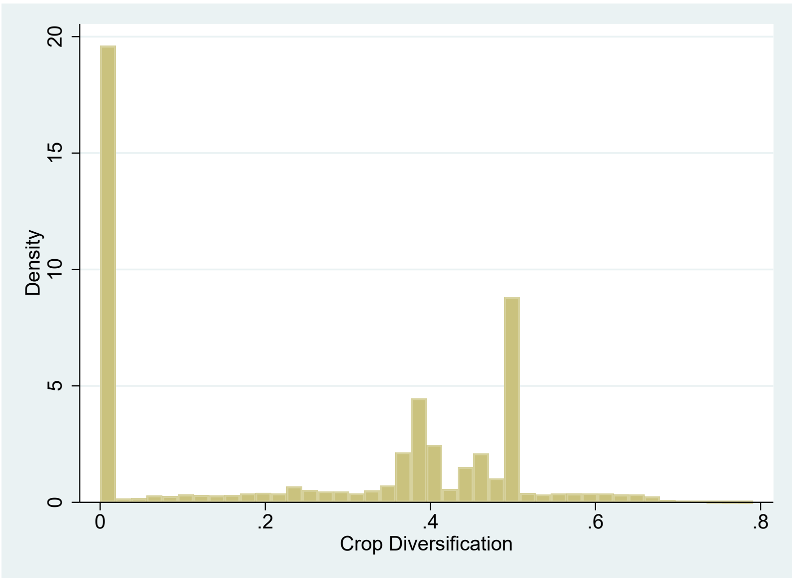
	Period	Mean	SD	Minimum	Maximum
Fatalities	**1997-2010**	71.38	167.48	0	6,466.25
(deaths)	**1997-2005**	69.40	162.19	0	6,441.44
	2006-2010	1.99	6.30	0	220.26
Number of Events	**1997-2010**	10.21	21.74	0	1,641.33
(events)	**1997-2005**	8.66	18.89	.05	1,542.01
	2006-2010	1.55	3.37	0	148.50

Figure 4: Conflict Intensity Index (log)



A.8 Crop Diversification Index

Figure 5: Crop Diversification Index

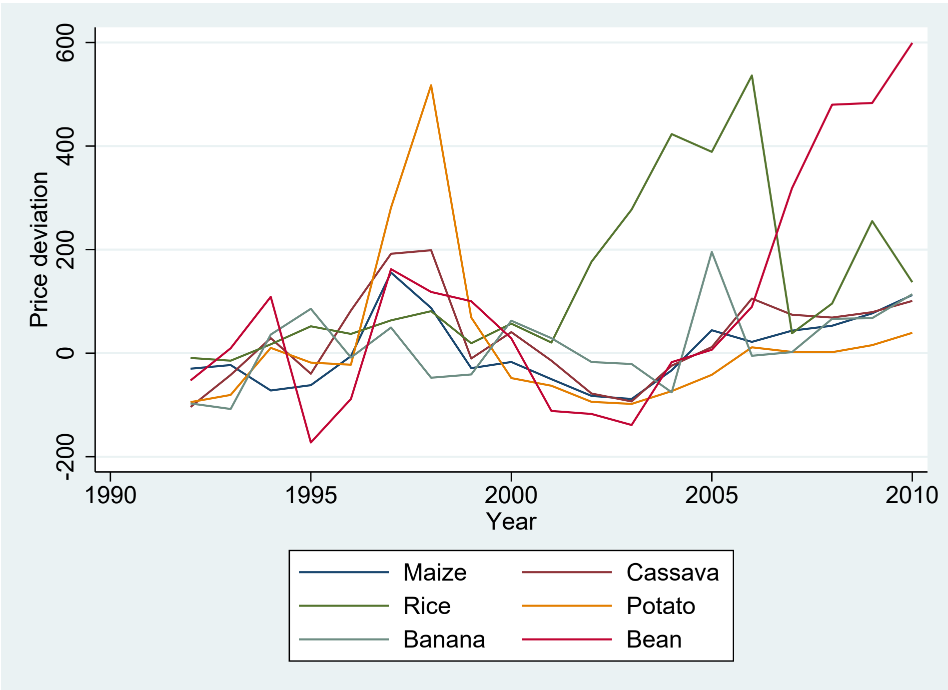


A.9 Consequences of Conflict

Table 9: Production Risk by Type of Crop

	$Var(y_1)$	$Var(y_2)$	ρ
Pre-Conflict (1991-1992)	144.94	103.77	0.89
Conflict (1993-2005)	192.95	147.88	-0.22
Post-Conflict (2006-2010)	410.23	326.98	0.97

Figure 6: Crop Price (Deviation from the 1991 price in USD, FAO)



B Empirical Results

B.1 Subsistence Farming

Table 10: Ratio of Safer Crops in Plot

Type of Plots	N	mean	sd
All plots	17,050	0.64	0.39
Monoculture	6,262	0.65	0.47
Polyculture	10,788	0.63	0.34

B.2 Crop Diversification

Table 11: Crop Diversification

	Conflict Intensity		Two Groups	
	(1) Whole	(2) Two Periods	(3) Poor vs. Non-Poor	(4) Sub-Sample
Conflict Intensity (1997-2010)	−0.005** (0.002)			
Conflict Intensity (1997-2005)		−0.006** (0.002)		
Conflict Intensity (2006-2010)		0.003 (0.003)		
Conflict Intensity X Poor			−0.004** (0.002)	
Conflict Intensity X Non-Poor			−0.002 (0.002)	
Conflict Intensity X Poor Upper				−0.006* (0.003)
Conflict Intensity X NonPoor Lower				−0.002 (0.003)
Observations	13403	13403	13403	6599
R-Squared	0.444	0.444	0.444	0.451
Plot characteristics	Y	Y	Y	Y
Household characteristics	Y	Y	Y	Y
Province FE	Y	Y	Y	Y

Standard errors are clustered at the area of 2X2km^2 for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 12: Crop Diversification: Chow Test for Two groups

Poor and Non-Poor

F(27, 3797)	p-value
4.55	0.0000

Poor Upper and Non-Poor Lower

F(27, 3797)	p-value
5.14	0.0000

B.3 Income Diversification

Table 13: Income Diversification

	Conflict Intensity		Two Groups	
	(1) Whole	(2) Two Periods	(3) Poor vs. Non-Poor	(4) Sub-Sample
Conflict Intensity (1997-2010)	0.005 (0.013)			
Conflict Intensity (1997-2005)		0.009 (0.014)		
Conflict Intensity (2006-2010)		−0.016 (0.023)		
Conflict Intensity X Poor			−0.006 (0.009)	
Conflict Intensity X Non-Poor			0.017* (0.010)	
Conflict Intensity X Poor Upper				0.014 (0.017)
Conflict Intensity X Non-Poor Lower				0.031* (0.018)
Observations	2381	2381	2381	1126
R-Squared	0.106	0.106	0.111	0.122
Household characteristics	Y	Y	Y	Y
Province FE	Y	Y	Y	Y

Standard errors are clustered at village level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Income Diversification: Chow Test for Two groups

Poor and Non-Poor

F(10, 315)	p-value
1.97	0.0362

Poor Upper and Non-Poor Lower

F(10, 316)	p-value
1.02	0.4258

B.4 Welfare

Table 15: Consumption

	Conflict Intensity		Two Groups	
	(1) Whole	(2) Two Periods	(3) Poor vs. Non-poor	(4) Poor Upper vs. Non-Poor Lower
Conflict Intenisty (1997-2010) X Asset	0.194**			
	(0.091)			
Conflict Intenisty (1997-2005) X Asset		0.238*		
		(0.129)		
Conflict Intenisty (2006-2010) X Asset		−0.106		
		(0.266)		
Conflict Intenisty (1997-2010) X Asset X Poor			0.374***	
			(0.081)	
Conflict Intenisty (1997-2010) X Asset X Poor Upper				0.160***
				(0.051)
Conflict Intenisty (1997-2010) X Asset X Non-Poor			−0.314***	
			(0.092)	
Conflict Intenisty (1997-2010) X Asset X Non-Poor Lower				−0.220**
				(0.091)
Observations	2241	2241	2241	1095
R-Squared	0.668	0.668	0.756	0.644
Household characteristics	Y	Y	Y	Y
Province FE	Y	Y	Y	Y

Standard errors are clustered at Colline level for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 16: Consumption: Chow Test for Two groups

Poor and Non-Poor

F(11, 312)	p-value
75.96	0.0000

Poor Upper and Non-Poor Lower

F(11, 312)	p-value
39.18	0.0000

B.5 Robustness

Figure 7: Crop Diversification Index: Comparison between OLS and IV

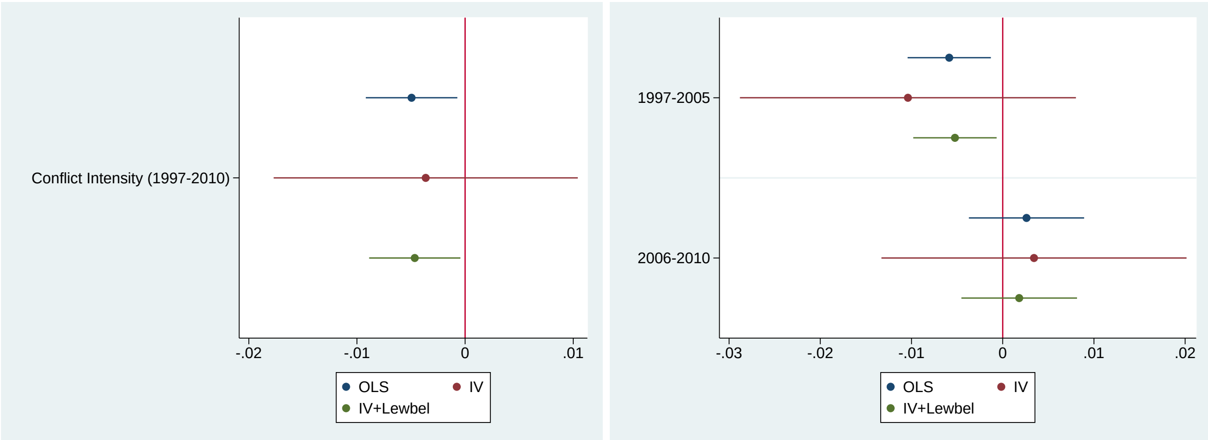


Figure 8: Income Diversification: Comparison between OLS and IV

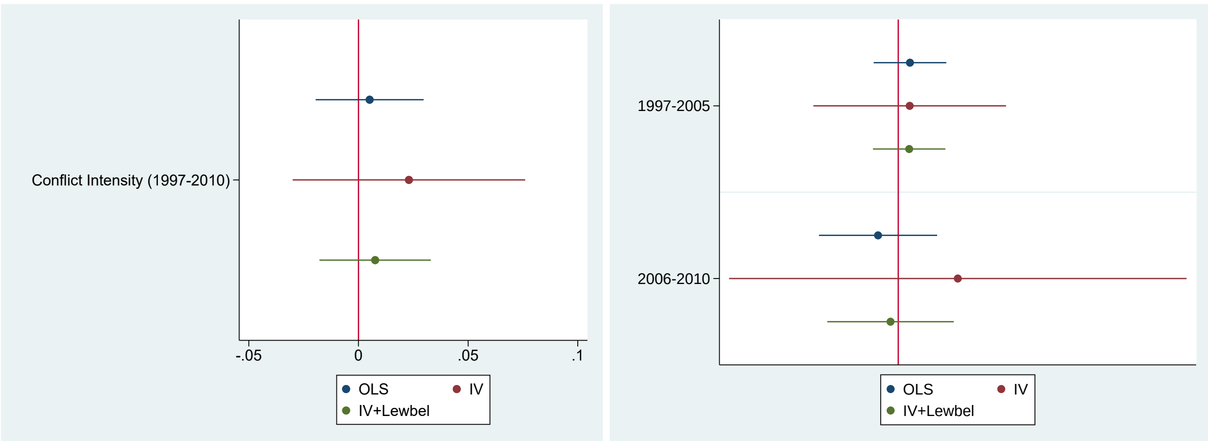


Table 17: Robustness: Crop Diversification

	First Stage (IV)	IV		IV + Lewbel	
	(1)	(2) Whole	(3) Two Periods	(4) Whole	(5) Two Periods
Distance to Capital	−0.021***				
	(0.001)				
Distance to Nearest Border	−0.013***				
	(0.002)				
Distance to Mpanda	−0.009***				
	(0.001)				
Conflict Intensity (1997-2010)		−0.003		−0.005**	
		(0.007)		(0.002)	
Conflict Intensity (1997-2005)			−0.002		−0.005**
			(0.008)		(0.002)
Conflict Intensity (2006-2010)			−0.002		0.002
			(0.007)		(0.003)
Observations	13403	13403	13403	13403	13403
F-stat	84.76				
Plot characteristics	Y	Y	Y	Y	Y
Household characteristics	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y

Standard errors are clustered at the area of $2X2km^2$ for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 18: Robustness: Income Diversification

	First Stage (IV)	IV		IV + Lewbel	
	(1)	(2) Whole	(3) Two Periods	(4) Whole	(5) Two Periods
Distance to Bujumbura	−0.031*** (0.005)				
Distance to Nearest Border	−0.013** (0.006)				
Distance to Mpanda	−0.016*** (0.004)				
Conflict Intensity (1997-2010)		0.023 (0.027)		0.008 (0.013)	
Conflict Intensity (1997-2005)			0.009 (0.038)		0.009 (0.014)
Conflict Intensity (2006-2010)			0.046 (0.090)		−0.006 (0.025)
Asset	−0.065 (0.213)	−0.122 (0.091)	−0.132 (0.094)	−0.125 (0.091)	−0.124 (0.090)
Observations	2381	2381	2381	2381	2381
F-stat	32.20				
Household characteristics	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y

Standard errors are clustered at village level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 19: Sensitivity Analysis: Crop Diversification

	Conflict Event		Total Fatalities		10 Km		UCDP-PRIO	
	(1) Whole	(2) Two Periods	(3) Whole	(4) Two Periods	(5) Whole	(6) Two Periods	(7) Whole	(8) Two Periods
Conflict Intensity (1997-2010)	−0.003		−0.004***		−0.003***		−0.004***	
	(0.003)		(0.002)		(0.001)		(0.002)	
Conflict Intensity (1997-2005)		−0.002		−0.004		−0.004***		−0.006***
		(0.004)		(0.003)		(0.001)		(0.002)
Conflict Intensity (2006-2010)		−0.001		−0.001		0.003		0.008*
		(0.004)		(0.002)		(0.003)		(0.004)
Observations	13403	13403	13403	13403	13403	13403	12575	12575
R-Squared	0.443	0.443	0.444	0.444	0.444	0.444	0.439	0.439
Plot characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Household characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y	Y	Y

Standard errors are clustered at the area of $2X2km^2$ for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 20: Sensitivity Analysis: Income Diversification

	Conflict Event		Total Fatalities		10 Km		UCDP-PRIO	
	(1) Whole	(2) Two Periods	(3) Whole	(4) Two Periods	(5) Whole	(6) Two Periods	(7) Whole	(8) Two Periods
Conflict Intensity (1997-2010)	0.013		0.003		0.009		0.008	
	(0.019)		(0.012)		(0.009)		(0.012)	
Conflict Intensity (1997-2005)		0.005		0.009		0.010		0.003
		(0.024)		(0.013)		(0.010)		(0.013)
Conflict Intensity (2006-2010)		0.018		−0.016		−0.001		0.026
		(0.034)		(0.014)		(0.023)		(0.029)
Observations	2381	2381	2381	2381	2381	2381	2247	2247
R-Squared	0.106	0.106	0.105	0.106	0.106	0.106	0.110	0.111
Household characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y	Y	Y

Standard errors are clustered at Colline level for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B.6 Composition of Crop Portfolio

Table 21: Ratio of Crops with Low Riskiness

	Ratio of Safer Crops	
	(1) Whole Period	(2) Two Periods
Conflict Intensity (1997-2010)	−0.006	
	(0.005)	
Conflict Intensity (1997-2005)		−0.008
		(0.005)
Conflict Intensity (2006-2010)		0.004
		(0.008)
Observations	13403	13403
R-Squared	0.054	0.054
Plot characteristics	Y	Y
Household characteristics	Y	Y
Province FE	Y	Y

Standard errors are clustered at the area of $2X2km^2$ for arbitrary spatial correlation.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C Theoretical Framework

In this Appendix we provide details of the farmer's problem in the household model presented in Section 3.

C.1 Derivation of Expected Utility

The farmer's problem is to maximize its utility under the budget constraints.

$$\max_{L_1,L_2,H} \quad \mathbb{E}u(c)$$
$$\text{s.t.} \quad c = y_1 + y_2 + wH \quad \text{where} \quad y_1 = \theta_1 f_1(L_1), \quad y_2 = \theta_2 f_2(L_2)$$
$$\text{and} \quad \Omega = L_1 + L_2 + H$$

The utility can be rewritten as

$$u(c) = -\exp\{-\gamma[(\theta_1 f_1(L_1) + \theta_2 f_2(L_2) + w(\Omega - L_1 - L_2))]\}$$

The expected utility is

$$\mathbb{E}(u(c)) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \exp\{-\gamma[(\theta_1 f_1(L_1) + \theta_2 f_2(L_2) + w(\Omega - L_1 - L_2))]\}g(\theta_1, \theta_2)d\theta_1 d\theta_2 \tag{4}$$

The maximization problem of the household is

$$\max_{L_1,L_2} - \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \exp\{-\gamma[(\theta_1 f_1(L_1) + \theta_2 f_2(L_2) + w(\Omega - L_1 - L_2))]\}g(\theta_1, \theta_2)d\theta_1 d\theta_2$$

The bivariate normal distribution is

$$g(\theta_1, \theta_2) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\exp\{-\frac{1}{2(1-\rho^2)}[(\frac{\theta_1-\mu_1}{\sigma_1})^2 - 2\rho(\frac{\theta_1-\mu_1}{\sigma_1})(\frac{\theta_2-\mu_2}{\sigma_2}) + (\frac{\theta_2-\mu_2}{\sigma_2})^2]\}$$

The expected utility (4) can be rewritten as

$$\begin{aligned}
\mathbb{E}[u(c)] = &- \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \exp\{-\gamma[\theta_1 f_1(L_1) + \theta_2 f_2(L_2) + w(\Omega - L_1 - L_2)]\} \\
&\exp\{-\frac{1}{2(1-\rho^2)}[(\frac{\theta_1-\mu_1}{\sigma_1})^2 - 2\rho(\frac{\theta_1-\mu_1}{\sigma_1})(\frac{\theta_2-\mu_2}{\sigma_2}) + (\frac{\theta_2-\mu_2}{\sigma_2})^2]\}d\theta_1 d\theta_2 \\
= &- \exp\{-\gamma w(\Omega - L_1 - L_2)\} \\
&\exp\{-\gamma\mu_1 f_1(L_1) - \gamma\mu_2 f_2(L_2) + \frac{\gamma^2[f_1(L_1)^2\sigma_1^2 + 2f_1(L_1)f_2(L_2)\rho\sigma_1\sigma_2 + f_2(L_2)^2\sigma_2^2]}{2}\}
\end{aligned}$$

With the given assumptions on the functional forms, the expected utility can be rewritten.

$$\mathbb{E}[u(c)] = -\exp\{-\gamma w(\Omega - L_1 - L_2) - \gamma\mu_1 L_1 - \gamma\mu_2 L_2 + \frac{\gamma^2\sigma^2}{2}(L_1^2 + 2\alpha\rho L_1 L_2 + \alpha^2 L_2^2)\}$$

C.2 Optimization Using Kuhn-Tucker Theorem

C.2.1 General Results

The objective function to maximize the expected utility with respect to labor choices is

$$\mathcal{L} = -\exp\{-\gamma[w(\Omega - L_1 - L_2) + \mu_1(1-\kappa)L_1 + \mu_2(1-\kappa)L_2] + \frac{\gamma^2\sigma^2(1-\kappa)^2}{2}(L_1^2 + 2\alpha\rho L_1 L_2 + \alpha^2 L_2^2)\}$$
$$- \lambda_1 L_1 - \lambda_2 L_2$$

The necessary conditions (Kuhn-Tucker conditions) to maximize the expected utility of the households are presented below.

$$
\begin{aligned}
& -exp\{.\}(\gamma[w - \mu_1(1-\kappa) + \gamma\sigma^2(1-\kappa)^2(L_1 + \alpha\rho L_2)]) - \lambda_1 \leq 0 \\
& L_1 \geq 0 \qquad \lambda_1 L_1 = 0 \\
& L_1(-exp\{.\}(\gamma[w - \mu_1(1-\kappa) + \gamma\sigma^2(1-\kappa)^2(L_1 + \alpha\rho L_2)]) - \lambda_1) = 0 \\
& -exp\{.\}(\gamma[w - \mu_2(1-\kappa) + \gamma\sigma^2(1-\kappa)^2(\alpha^2 L_2 + \alpha\rho L_1)]) - \lambda_2 \leq 0 \\
& L_2 \geq 0 \qquad \lambda_2 L_2 = 0 \\
& L_2(-exp\{.\}(\gamma[w - \mu_2(1-\kappa) + \gamma\sigma^2(1-\kappa)^2(\alpha^2 L_2 + \alpha\rho L_1)]) - \lambda_2) = 0 \\
& \lambda_1 \geq 0 \qquad \lambda_2 \geq 0
\end{aligned}
$$

As the following conditions are satisfied,
(i) $u(c)$ is differentiable and concave in the nonnegative orthant
(ii) contraints $f(L_i) \quad (i = 1,2)$ is differentiable and convex in the nonnegative orthant
there is a point that maximizes the objective function that satisfies the Kuhn-Tucker conditions

1. $L_1 = 0$ and $L_2 > 0$

    - When $\rho < 0$, there is no interior solution

- When $0 < \alpha \leq \frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w}$ and $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$, the labor allocation is decided as follows.

$$L_1^* = 0$$
$$L_2^* = \frac{\mu_2(1-\kappa)-w}{\gamma\alpha^2\sigma^2(1-\kappa)^2}$$
$$H^* = \Omega - \frac{\mu_2(1-\kappa)-w}{\gamma\alpha^2\sigma^2(1-\kappa)^2}$$

2. $L_1 > 0$ and $L_2 = 0$

- When $\rho < 0$, there is no interior solution
- When $\frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w} < \alpha \leq 1$ and $\frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w} \leq \rho \leq 1$, the labor allocation is decided as follows.

$$L_1^* = \frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2(1-\kappa)^2}$$
$$L_2^* = 0$$
$$H^* = \Omega - \frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2(1-\kappa)^2}$$

3. $L_1 > 0$ and $L_2 > 0$

- When $w < 1$ and $\frac{1}{2} < \rho < 1$, there is no interior solution.
- When $0 < \alpha \leq \frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w}$ and $-1 \leq \rho \leq \frac{\alpha(\mu_1(1-\kappa)-w)}{\mu_2(1-\kappa)-w}$, or $\frac{\mu_2(1-\kappa)-w}{\mu_1(1-\kappa)-w} < \alpha \leq 1$ and $-1 \leq \rho \leq \frac{\mu_2(1-\kappa)-w}{\alpha(\mu_1(1-\kappa)-w)}$, the labor allocation for the two farming activities are decided as follows.

$$L_1^* = \frac{\alpha(\mu_1 - w) - \rho(\mu_2 - w)}{\gamma\alpha\sigma^2(1-\rho^2)}$$
$$L_2^* = \frac{(\mu_2 - w) - \alpha\rho(\mu_1 - w)}{\gamma\alpha^2\sigma^2(1-\rho^2)}$$
$$H^* = \Omega - \frac{(1-\alpha\rho)(\mu_2 - w) + \alpha(\alpha-\rho)(\mu_1 - w)}{\gamma\alpha^2\sigma^2(1-\rho^2)}$$

C.2.2 Results with Restriction in Labor Allocation in Less Risky Activity

The objective function to maximize the expected utility with respect to labor choice of L_1 is

$$\mathcal{L} = -\exp\{-\gamma w(\Omega - L_1 - \widetilde{L_2}) - \gamma\mu_1(1-\kappa)L_1 - \gamma\mu_2(1-\kappa)\widetilde{L_2} + \frac{\gamma^2\sigma^2(1-\kappa)^2}{2}(L_1^2 + 2\alpha\rho L_1\widetilde{L_2} + \alpha^2\widetilde{L_2}^2)\} - \lambda_1 L_1$$

The necessary conditions (Kuhn-Tucker conditions) to maximize the expected utility of the households are

$$
\begin{aligned}
& -exp\{.\}(\gamma[w-\mu_1(1-\kappa)+\gamma\sigma^2(1-\kappa)^2(L_1+\rho\widetilde{L_2})]-\lambda_1 \le 0 \\
& L_1 \ge 0 \qquad \lambda_1 L_1 = 0 \\
& L_1(-exp\{.\}(\gamma[w-\mu_1(1-\kappa)+\gamma\sigma^2(1-\kappa)^2(L_1+\rho\widetilde{L_2})]-\lambda_1)=0 \\
& \lambda_1 \ge 0
\end{aligned}
$$

The optimal allocation of labor is
If $-1 \le \rho \le \frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2\widetilde{L_2}(1-\kappa)^2}$,

$$
\begin{aligned}
& L_1^* = \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2} \\
& L_2 = \widetilde{L_2} \\
& H^* = max\{0, \quad \Omega - \widetilde{L_2} - \frac{\mu_1 - w - \gamma\sigma^2\rho\widetilde{L_2}}{\gamma\sigma^2}\}
\end{aligned}
$$

If $\frac{\mu_1(1-\kappa)-w}{\gamma\sigma^2\widetilde{L_2}(1-\kappa)^2} \le \rho \le 1$,

$$
\begin{aligned}
& L_1^* = 0 \\
& L_2 = \widetilde{L_2} \\
& H^* = max\{0, \quad \Omega - \widetilde{L_2}\}
\end{aligned}
$$

C.3 Welfare Implication of Diversification

C.3.1 Changes in Parameters and Expected Utility

Let C be the level of conflict intensity to which a farmer has been exposed. Higher risk of violence will increase production risk in farming activities and probability of $\widetilde{L_2} > L_2^*$.

$$
\frac{d\sigma(C)}{dC} > 0 \qquad \frac{d\mathbb{1}(\widetilde{L_2}(C))}{dC} > 0
$$

where $\mathbb{1}(\widetilde{L_2}(C))$ is an indicator function

$$
\mathbb{1}(\widetilde{L_2}(C)) = \begin{cases} 1, & \text{if} \quad \widetilde{L_2} > L_2^* \\ 0, & \text{if} \quad \widetilde{L_2} \le L_2^* \end{cases}
$$

Applying the Envelope Theorem, we conclude that the marginal expected utility of the farmer decreases as the conflict intensity increases through different channels mentioned above.

$$\frac{\partial E(u)}{\partial C} < 0$$

C.3.2 Role of Assets in Welfare of Households

Now we assume that a household has external sources of income, S, which is added in the consumption equation, $c = y_1 + y_2 + wH + S$ where S indicates assets of households including livestock, savings, interest or credit.

Addition of S does not change the optimal level of Labor allocation of L_1, L_2, and H with the given endowment, but the expected utility depends on the level of S.

$$\mathbb{E}(u) = -\exp\{-(y_1 + y_2 + wH + S)\}$$

High level of assets of household can compensate for the negative effects of exposure to high risk of violence.

$$\frac{\partial^2 E(u)}{\partial C \partial S} > 0$$

D Stochastic Frontier Estimation

We estimate the technical inefficiency of crop production at plot level using stochastic frontier estimation (Aigner et al., 1977).

$$y_i = f(x;\beta) + exp(\epsilon_i)$$
$$\epsilon_i = v_i - u_i$$

where $f(x;\beta)$ is the deterministic kernel and the composite error $exp(\epsilon_i)$ consists of two elements: $exp(v_i)$ is the exogenous shocks and $exp(-u_i)$ is technical inefficiency. v_i is identically distributed (iid), symmetric, and distributed independently from u_i. u_i is assumed to follow half-normal distribution (Aigner et al., 1977; Jondrow et al., 1982; Battese and Coelli, 1992, 1995).

$$v_i \sim \mathcal{N}(0, \sigma_v^2)$$

$$u_i \sim \mathcal{N}^+(\mu, \sigma_u^2)$$

The empirical model is specified as below

$$lny_i = \beta_0 + \beta_1 lnL_i + \beta_2 lnK_i + v_i - u_i$$

K is the area of the plot and L is the number of labor used for the plot. We assume that other inputs are proportional to the land size. We estimate parameters by likelihood-based techniques (Battese and Coelli, 1988), The log likelihood function assuming a half normal distribution on u_{it} is

$$ln(L) = \frac{N}{2}(ln2\pi + ln\sigma^2) + \sum_{i=1}^{N}[ln\phi[-\epsilon_i \lambda/\sigma] - \frac{1}{2}(\epsilon_i/\sigma)^2]$$

The technical inefficiency is

$$TE_i = exp(-u_i) = \frac{y_i}{f(x;\beta)exp(v_i)}$$

E Robustness: Lewbel Estimation

To correct endogeneity from measurement errors of the conflict intensity indicator, we follow the internal instrument variable approach suggested by Lewbel (Lewbel, 2012).

E.1 Assumptions and Construction of Instruments

Assume that the conflict intensity, the conflict intensity, C_{chp}, is endogenous as it is correlated with the village characteristics, λ_c.

$$y_{chp} = C_{chp}\beta + x_{chp}\delta_{1x} + u_{1chp} \qquad (u_{1chp} = \lambda_c + \epsilon_{1chp}) \tag{5}$$
$$C_{chp} = x_{chp}\delta_{2x} + u_{2chp} \qquad (u_{2chp} = \lambda_c + \epsilon_{2chp})$$

Besides the standard assumption that x_{chp} is uncorrelated with λ_c, ϵ_{1chp} and ϵ_{2chp}, we assume that z_{chp}, a subset of x, is orthogonal to λ_c^2, $\lambda_c\epsilon_{jchp}$, and $\epsilon_{1chp}\epsilon_{2chp}$. We further assume that there is heteroskedasticity in the data.

$$Cov(z_{chp}, \epsilon_{1chp}) = 0$$
$$Cov(z_{chp}, \epsilon_{2chp}) = 0$$
$$Cov(z_{chp}, \epsilon_{1chp}\epsilon_{2chp}) = 0$$
$$Cov(z_{chp}, \epsilon_{2chp}^2) \neq 0$$

With the assumptions above, $(z_{chp} - \mathbb{E}(z_{chp}))u_{2chp}$ is a valid instrument which is correlated with C_{chp} and not correlated with u_{1ch}.

$$\begin{aligned} Cov(z_{chp}u_{2chp}, C_{chp}) &= Cov(z_{chp}u_{2chp}, x_{chp}\delta_{2x} + \lambda_c + \epsilon_{2chp}) \\ &= Cov(z_{chp}u_{2chp}, x_{chp}\delta_{2x}) + Cov(z_{chp}u_{2chp}, \lambda_c) + Cov(z_{chp}u_{2chp}, \epsilon_{2chp}) \\ &= Cov(z_{chp}\epsilon_{2chp}^2) \neq 0 \end{aligned}$$

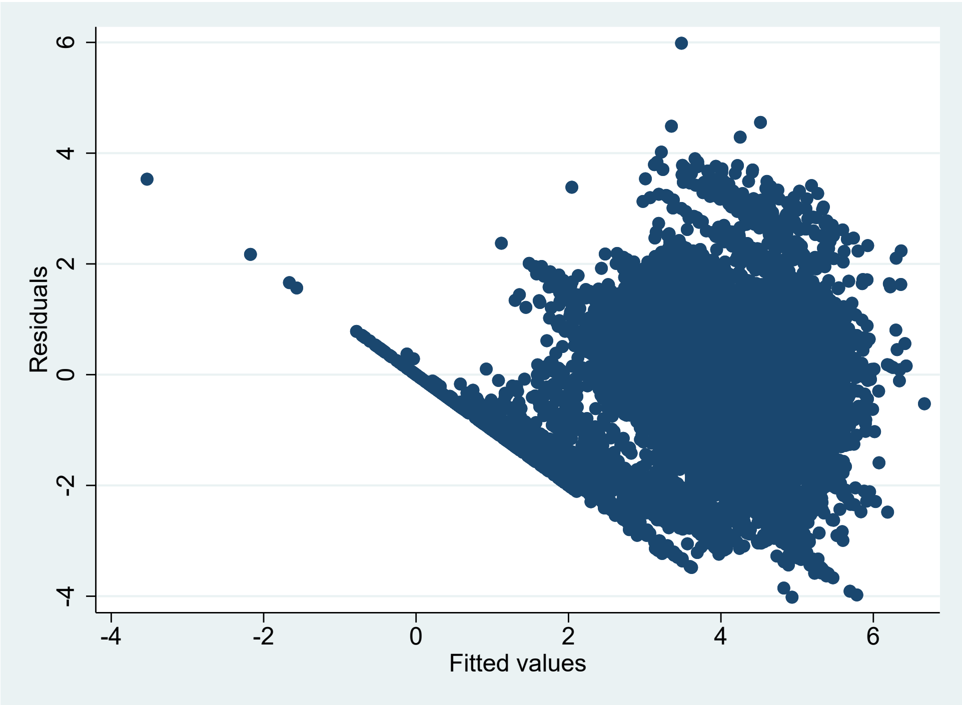
$$\begin{aligned} Cov(z_{chp}u_{2chp}, u_{1chp}) &= \mathbb{E}(z_{chp}u_{2chp}, u_{1chp}) - \mathbb{E}(z_{chp}u_{2chp})\mathbb{E}(u_{1chp}) \\ &= \mathbb{E}(z_{chp}u_{2chp}(\lambda_c + \epsilon_{1chp}) - \mathbb{E}(z_{chp}(\lambda_c + \epsilon_{1ch}))\mathbb{E}(\lambda_c + \epsilon_{1ch}) \\ &= \mathbb{E}(z_{chp}u_{2chp}\lambda_c) + \mathbb{E}(z_{chp}u_{2chp}\epsilon_{1chp}) - (\mathbb{E}(z_{chp}\lambda_c) + \mathbb{E}(z_{chp}\lambda_c\epsilon_{1chp}))\mathbb{E}(\lambda_c + \epsilon_{1chp}) \\ &= 0 \end{aligned}$$

The parameters β and δ_{1x} are identified by two-stage least squares regression of y_{chp} on x_{chp} and C_{chp} using z_{chp} and $(z_{chp} - \mathbb{E}(z_{chp}))u_{2chp}$ as instruments.

E.2 heteroskedsasticity of Conflict Intensity

Figure 9 is the scatter plot of the predicted values and the residuals when conflict intensity is regressed on all other exogenous variables. The Breusch-Pegan test (Table 22) confirms the heteroskedastic nature of conflict intensity. We use this to formulate the Lewbel estimator.

Figure 9: Heteroskedasticity of Conflict Intensity



Residuals are plotted over the fitted values from the regression of the conflict intensity on other exogenous covariates.

Table 22: Heteroskedasticity Test of Conflict Intensity

Variable	chi2(26)	P-value
Conflict Intensity	650.30	0.0000