Food crop diversification as a risk mitigating strategy during conflict : evidence from Cote d'Ivoire

INSTITUTE OF DEVELOPING ECONOMIES

IDE Discussion Papers are preliminary materials circulated to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 496

Food Crop Diversification as a Risk Mitigating Strategy during Conflict: Evidence from Cote d'Ivoire

Saumik PAUL*, Abu S. SHONCHOY ** and Andrew DABALEN***

February 2015

Abstract

This study examines the significance of food crop diversification as a household risk mitigating strategy to achieve "self-sufficiency" to ensure food security during the civil conflict in Cote d'Ivoire. The main motivation for seeking self-sufficiency stems from the fact that during the period of heightened tension due to conflict, the north–south divide set by the UN peacekeeping line disrupted the agricultural supply chain from the food surplus zone, Savane in the north. While we theoretically predict a positive effect on crop diversification because of interrupted food supply chain, we also consider a negative effect due to the covariate shocks. We find robust and statistically significant empirical outcomes supporting such claims. The baseline outcomes withstand a series of robustness checks. The net effect of conflict on crop diversification is positive but not statistically significant. In addition, we find that increasing vulnerability to poverty and food insecurity during conflict seems to be the underlying factors that motivate farm households to adopt such coping strategies

Keywords: conflict, uncertainty, agricultural production, developing countries
JEL classification: D13, D74, Q1

---

*University of Nottingham, Malaysia Campus (paulsaumik@gmail.com); **Institute of Developing Economies-JETRO (parves.shonchoy@gmail.com); ***World Bank

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

Food Crop Diversification as a Risk Mitigating Strategy during Conflict: Evidence from Cote d'Ivoire

Saumik Paul*, Abu Shonchoy** and Andrew Dabalen***

Abstract

This study examines the significance of food crop diversification as a household risk mitigating strategy to achieve "self-sufficiency" to ensure food security during the civil conflict in Cote d'Ivoire. The main motivation for seeking self-sufficiency stems from the fact that during the period of heightened tension due to conflict, the north–south divide set by the UN peacekeeping line disrupted the agricultural supply chain from the food surplus zone, Savane in the north. While we theoretically predict a positive effect on crop diversification because of interrupted food supply chain, we also consider a negative effect due to the covariate shocks. We find robust and statistically significant empirical outcomes supporting such claims. The baseline outcomes withstand a series of robustness checks. The net effect of conflict on crop diversification is positive but not statistically significant. In addition, we find that increasing vulnerability to poverty and food insecurity during conflict seems to be the underlying factors that motivate farm households to adopt such coping strategies.

Keywords: Conflict, uncertainty, agricultural production, developing countries

JEL codes: D13, D74, Q1

Authors' affiliations:
*University of Nottingham, Malaysia Campus (paulsaumik@gmail.com); **Institute of Developing Economies-JETRO (parves.shonchoy@gmail.com); ***World Bank

The authors are grateful to the Institute of Developing Economies (IDE-JETRO) for their logistic support during the preparation of this research output. We are grateful to seminar participants at IDE-JETRO, particularly to Shinichi Takeuchi, Yuya Kudo, Tomohiro Machikita, and Kazushi Takahasi for their insightful comments. We thank Jonathan Fortun, Keshni Sritharan, and Venga Sarma for excellent research assistance. The findings, interpretations, and conclusions expressed in this study are entirely those of the authors. The usual disclaimer applies.

I. Introduction

Common strategies undertaken by poor households in rural areas during a protracted crisis include immediate diversification of land holdings, prolonged stores of grains, atypical sales and purchases of assets such as land, financial borrowing from moneylenders, and the utilization of transfers and non-money transactions relying on family or related networks (Townsend, 1995). This study examines household coping mechanisms during civil conflict that can be considered the most powerful political economic factor dictating policy, strategy, and performance in agriculture since the late nineties in Cote d'Ivoire (Abbott, 2007). The civil conflict that erupted in 2002 due to political instability and massive population displacement disrupted the country's socioeconomic development. It divided the country into two halves—the tropical rainforest in the south, controlled by the government, and the Savane of the north, controlled by opposition forces. During this period, the average real GDP grew at the rate of −0.4 percent per year. The livelihood of rural households substantially declined in the absence of a central administration (FAO, 2009) and the rural poverty rate rose from 46 percent in 2002 to 55 percent in 2008 (Dabalen and Paul, 2013).

According to Abbott (2007), the civil conflict influenced the specifics of agricultural policy through the north–south division of the country and through impacts of immigrant labor from neighboring countries. While the tropical rainforests in the south are the primary sources of cash crops, cocoa, coffee, and some tropical fruits, the Savane of the north has traditionally supplied the majority of the food crops such as rice, maize, sorghum, and millet, among others. Unlike cash crops, which have been the main sources of export earnings, food crops are mostly non-tradable except that half of the country's rice consumption is met through imports (Abbott, 2007). Collectively, non-tradable food crops and rice constitute more than one-third of the total value of agricultural production. The north–south division demarcated by the enforcement of the UN peacekeeping line disrupted the food supply chain from the north to the rest of the country. Presumably, this had differential effects on agricultural strategies between the north and the south.

More specifically, in the pre-conflict period, more than 10% of the farmers in the South Forest grew cassava as their only food crop; however, in the post-conflict

period, a sizable portion of farmers also grew rice, maize, sorghum, vegetables, etc. However, the overall level of food crop diversification in the Savane indicated a relatively consistent trend between the pre-conflict and the post-conflict periods (Paul, 2014). This changing pattern of crop choice during the conflict period, especially in the South Forest, is suggestive of crop diversification as a coping strategy to achieve food self-sufficiency in the face of the conflict (Brück & Schindler, 2008). Building on a theoretical model elucidating the relationship between crop diversification and risk mitigation, we perform an empirical analysis to assess whether crop diversification has served as a coping mechanism for households facing the risk of conflict and the resulting price shocks in Cote d'Ivoire. We draw insights from numerous events associated with the Ivoirian conflict that provide anecdotal evidence of the utilization of crop diversification as a tool to smooth consumption and maintain standards of living during conflict.

Lately, there has been a surge in the literature examining the coping mechanisms used by households to mitigate risks from civil conflicts (Justino, 2009), wherein this study's contribution squarely fits. Numerous coping strategies adopted by households in Africa revolve around the sole word, "agriculture." This is not so surprising, as up to 70 percent of households in Africa depend on agriculture for their food supply (Chenje et al, 2006). Justino (2010) observes that households residing in an area of conflict or in camps allocated for the refugees as well as internally displaced persons tend to depend on cultivating crops that are perceived as low risk, a characteristic that tends to go hand in hand with low returns. These households believed that if they can access land, they could make use of the available labor supply and thus feed their families. Rockmore (2012), in another study on Uganda, finds that while income sources and labor allocation remain largely unchanged, large changes occur in terms of livestock portfolio and the choice of crops. Similar evidence was found in several other studies, including those of Bundervoet (2007) on Burundi and Vlassenroot (2008) on Congo. In a recent study on Colombia, Arias, Ibáñez and Zambrano (2013) show that conflict affects agricultural production through different channels and households habituate to conflict, but at a lower equilibrium. Recent presence of conflict induces farmers to curtail farming perennial crops, pasture, and investments. However, in a prolonged crisis, farmers increase land use for perennial crops and pasture, and investments rebound.

We build a theoretical model based on the premise that agricultural households in Cote d'Ivoire face two correlated conflict shocks. First, direct effects reduce productivity and output as conflict forces farm households to produce less than optimum outputs due to lack of input supplies and physical risk of operating the farms. The second channel of risk for farm households during conflict occurs through interruptions to the food supply chain due to the UN peacekeeping line, which divided Cote d'Ivoire into two regions, the northern Savane and the south forest region. Using a theoretical framework based on the excepted value variance (EV) approach (Robinson and Barry, 1987), we explain the risk mitigating strategies of farm households based on their food crop choices (number of food crops) under the threat of a conflict. Based on our theoretical model, we derive two testable hypotheses. First, crop diversification is more attractive where the price fluctuation risk of food crops is substantial, which results from the disruption of the food supply chain. Second, crop diversification is less attractive in the presence of high correlated shocks, as explained by the direct effects of conflict.

For empirical tests, we use data from two rounds of Cote d'Ivoire's nationally represented household survey, ENV-2002 and ENV-2008, bracketing the conflict peak period from 2003 to 2006. We also use the Armed Conflict Location and Event Database (ACLED) to measure the intensity of conflict across regions and departments. To identify the indirect effects through price volatility, we use pre- and post-conflict periods and variations in crop diversification between the northern region of Savane and the southern region of South Forest. Consistent with our theoretical argument, we find that in 2008, farm houeholds were more likely to adopt the practice of multi-cropping in South Forest compared to Savane. Furthermore, we use variations in the intensity of conflict across departments in the South Forest region to identify the direct effects of the conflict. Since food crop production in Savane has tradionally been high, we examine only the South Forest region, an approach explained in subsequent sections. Empirical findings reveal that farmers in the conflict-affected zones would be approximately 10 percent less likely to adopt multi-cropping compared with those in no conflict zones in the South Forest region. Overall, we find robust and statistically significant evidence supporting the impact of both the direct and indirect channels of conflict on crop diversification.

We conduct numerous robustness checks to examine whether the baseline outcomes are biased by endogeneity issues, omitted variables, and household-specific unobservable factors. We use income inequality at the department level as an instrument, and the instrumental variable regression outcomes are in line with baseline results. Since the main independent variables identifying the effect of conflict take a limited number of possible values, we run a regression at the department level. This further enables us to explore the net effect considering both the direct and indirect effects of conflict. The net effect of conflict on crop diversificatin is positive but not statistically significant. As our next robustness check, we follow the strategy proposed by Altonji, Elder, Conley, and Taber (2005) using selection on observables to estimate the potential bias from unobservables. The outcomes on this test imply that the selection on unobservables in our models, on average, need to be approximately five times stronger to explain the estimated coefficients. Thus, our baseline estimated regression outcomes are less likely to be biased by unobservables. The outcomes are consistent with alternative measure of the direct effects of conflict using conflict victimization variables. We also show that indirect effects of conflict do not lead to cash crop diversification, which otherwise would make our causal argument less credible. This falsification test confirms that the disruption of food supply chain only resulted in food crop diversification to attain food supply self-sufficiency at the household level. Finally, we delineate some persistent channels that might lead conflict-affected households to opt for food crop diversification. We find that increasing vulnerability in terms of both poverty condition and food insecurity plays a crucial role.

The remainder of the study is organized as follows. Section II provides a brief historical account of the Ivoirian civil conflict. Section III provides a descriptive evidence on crop diversification before and after the civil conflict's peak. Section IV presents a theoretical model on household coping strategies using crop diversification. Section V summarizes the empirical model and key findings. Section VI discusses outcomes from some robustness tests. Section VII presents a discussion on the possible welfare channels resulting from the food crop diversification. This is followed by a concluding note.

II. Brief description of the Ivoirian civil conflict

A. Economic stagnation and political crisis preceeding the conflict

Côte d'Ivoire, which was a role model of success in sub-Saharan Africa in the 1960's, fell into civil and armed conflicts due to reasons such as establishment of ethnic quotas in the political system, worldwide recession with associated volatility in cocoa and coffee prices, and structural adjustment programs offered by the World Bank and the International Monetary Fund. The first round of armed conflict in Côte d'Ivoire started in September 2002 but lasted only a few months. The National Army (FANCI) was joined by the Young Patriots, a youth militia that supported President Gbagbo. On the other hand, a few small rebel groups such as the *Movement for Justice and Peace* (MJP), the *Movement of the Ivory Coast of the Great West* (MPIGO) and supporters of Outarra joined together under the banner *Forces Nouvelles* (FN) led by Guillame Soro. The first peace agreement between the two opposing forces, the Linas-Marcoussis, was signed in January 2003. The *Forces Nouvelles* took charge of the Ministry of Defense and the Ministry for the Interior. Around the same time, French troops and the UN peacekeeping force formed a narrow "peace belt," which constituted a line of control near the religious fault line (see Figure 1). Since then, numerous peace agreements have been signed between President Gbagbo and opposition forces, but tensions remained until 2007, when Guillame Soro became Prime Minister under Gbagbo. Both sides agreed to a free and fair general election to be held in 2008.

[Figure 1 is about here]

This long-anticipated presidential election occurred at the end of 2010, after six postponements. The presidential contest morphed into a political stalemate with a deadly power struggle between the renegade incumbent Laurent Gbagbo—who refused to relinquish power despite losing the election—and Alassane Ouattara, who received the chance to stand in the election in 2011 and was declared winner by the Electoral Commission. Despite growing international pressure, Gbagbo refused to leave office, which initiated fresh spells of violence, and Côte d'Ivoire remained on the verge of another deadly civil conflict. When world leaders interfered, Gbagbo was forced to stand down in April 2011, and since then Ouattara has been Côte d'Ivoire's president.

B. Incidences of conflict

Data on local incidences of civil conflict are taken from Armed Conflict Location and Event Database (ACLED) for the period 1997 to 2008. To match with conflict outcomes, we construct potential causal factors using household level demographic and socioeconomic information from the Enquete sur le Niveau de Vie de Menage (ENV) survey data administered in Cote d'Ivoire. We use three rounds of nationally represented ENV data—1998, 2002, and 2008.

[Figure 2 is about here]

ACLED[1] (Raleigh, Hegre, and Carlson, 2009) compiles exact locations, dates, and additional characteristics of individual battle events in states affected by civil conflict. The conflict data for Cote d'Ivoire is available for the period from 1997 to 2010. It tracks rebel activity and distinguishes between territorial transfers of military control from governments to rebel groups and vice versa. The conflict events were disaggregated into six categories: (i) Battle–government regains territory, (ii) Battle–no change of territory, (iii) Battles–rebels overtake territory, (iv) Non-violent activity by a conflict actor, (v) Riots/protests, and (vi) Violence against civilians. Figure 3 indicates the total number of reported conflicts per year. In our study period, the frequency of conflict events follows a twin-peaked distribution. The first peak is around 1999–2000, and the second peak occurs between 2002 and 2006, when the conflict was at its most violent. The ACLED on Cote d'Ivoire reports a total number of 965 armed conflict events for the period 1998 to 2008.

[Figure 3 is about here]

As per the 1998 Census, Cote d'Ivoire is divided into 50 departments. ACLED provides the exact locations of the civil conflict events. Using data on their latitude

[1] For more information please see the ACLED website located at http://www.prio.no/CSCW/Datasets/Armed-Conflict/Armed-Conflict-Location-and-Event-Data/

and longitude, we map these conflict events onto these 50 departments using spatial coordinates taken from the DIVA-GIS[2] website. In Figure 3, we plot the total number of events at the department level for two periods: from 1998 to 2002 and from 2003 to 2008, respectively. In both parts of the figure, the regions marked with darker shading refer to a higher frequency of conflict events. These graphs indicate that incidences of civil conflict have been more frequent in the western and southern parts of Core d'Ivoire and in the neighborhood of Abidjan. In 2003, the number of armed conflict events exceeded 150. Table 1 presents the descriptive statistics on conflict counts at the department level (N = 50). The average conflict counts were higher in the period 1999–2002 compared to 2003–2006. The average number of conflict events per department stood at 9.16 and 8.58 in the periods 1999–2002 and 2003–2006, respectively.

[Table 1 is about here]

III. Crop diversification before and after the Conflict

In Cote d'Ivoire, approximately 68% of the labor force engages in agricultural activities. Before independence, the French colonial legacy heavily influenced Cote d'Ivoire's agricultural policy through the establishment of infrastructure and institutional structures. Traditionally, agricultural policy in Cote d'Ivoire discouraged food crop production, against the wishes of farmers, by focusing on export crops at the expense of food production. In the 1920s, cocoa and coffee plantations were established alongside smallholder farms; cotton was also introduced around the same time (FAO, 2003). For decades, the Republic of Cote d'Ivoire has primarily remained an export-oriented agricultural economy characterized by smallholder farming and cash crops[3] as the main sources of revenue. However, volatility in global cocoa and coffee prices since the late 1980s and price uncertainty following the liberalization of the cocoa and coffee marketing board in 1999 substantially declined farmers'

[2]DIVA-GIS website for Cote d'Ivoire http://www.diva-gis.org/datadown

[3] Cocoa, coffee, cotton, rubber etc.

participation in cocoa and coffee farming (Dabalen, Essama-Nssah & Paul, 2010). In addition, the cotton crisis since 2004 and a poor cashew harvest in 2006 increased the cultivation of food crops by replacing some of the existing cash crop activities (FAO, 2010).

The total agricultural production in Cote d'Ivoire can be divided into two distinct parts—the tropical rainforests in the south and the Savane of the north. The majority of the food crops (rice, maize, sorghum, millet, cassava, yams, etc.) are grown in the Savane, located in the country's north. The tropical rainforest in the south cultivates mainly cash crops, cocoa and coffee, as well as some vegetables, plantains, and tropical fruits. Unlike cash crops, which have traditionally been then the main sources of export earnings, food crops are mostly non-tradable except that half of the rice consumption is met through imports (nearly 3 percent of total imports in 2004). Rice is mostly grown in the Savane, along with cotton, maize, and cassava. However, limited amount of rice is grown in the forest areas of the southwest. Non-tradable food crops and rice constitute more than one-third of the total value of Cote d'Ivoire's agricultural production, but there exist little evidence regarding the welfare consequences of rising food prices upon farmers growing these crops.

[Figure 4 is about here.[4]]

The north–south divide established by the UN peacekeeping line disrupted the agricultural value chain, although cocoa exports remained steady despite the conflict. Cotton production, which is concentrated in the Savane, came under the control of rebels during the civil conflict and a sizable share of its produce was sold informally, through smuggling, in neighboring Mali and Burkina Faso, increasing traders' margins and distorting the management of the cotton sector (OT Africa Line, 2006). This deteriorated financial circumstances for Ivorian cotton companies. Moreover, it became increasingly difficult to obtain credit during this period, partly due to the conflict and due to structural adjustment reforms. As a result, recent years have seen food crops and cash crops other than cocoa and coffee grow in importance.

[4] For analytical purpose, we divide the Cote d'Ivoire into two regions: Savane and South Forest, as shown in Figure 4. Savane, the northern part of Cote d'Ivoire, comprises six regions: Savane, Denguele, Baffing, Wordougou, Valle Du Bandama, and the northern part (Bouna department) of Zanzan. The South Forest region in the south comprises five regions: Moyen Cavaly, Bas Sassandra, Sud Bandama, Lagunes, and Fromager.

Figure 5 compares the shares of food crop cultivators and gross sellers between 2002 and 2008. As evident from panel A1 of Figure 5, food crop farmers are predominantly located in the Savane and other regions. In both regions, on average more than one-third of the total population is devoted to food cropping whereas approximately one-tenth of South Forest's population cultivates food crops. This difference holds for gross sellers of food crops (panel A2) as well. In 2002, on average only 2 percent of the population in the South Forest region were recorded as gross sellers of food crops. This indicates that before conflict emerged, the northern and central parts of Cote d'Ivoire remained the main source in the food supply chain. However, numbers of food croppers between 2002 and 2008, which marks the peak of civil conflict, significantly increased in the South Forest region. Rice cultivators grew by approximately 99 percent whereas the growth in yam cultivators was recorded at 160 percent. Other crops show similar increases in the number of farmers, except for cassava. While the increase in food crop farming was moderate in other regions during the same timeframe, the growth of food croppers in Savane region was negligible. A mirror image of this phenomenon can be seen in the growth of gross sellers as presented in panel B2. Overall, the descriptive evidence on food crop farming indicates that the cultivation and sales of food crops significantly increased in the southern parts of Cote d'Ivoire. This strengthens the argument for crop diversification in the southern regions, which was predominantly a cash crop growing region prior to the conflict.

[Figure 5 is about here]

Next, Figure 6 compares the distribution of net sellers and gross sellers based on farm holding size between the Savane and South Forest regions. If a farm household sells a higher quantity than that retained for its own consumption for a particular crop, then we consider it a net seller. In Figure 7, net sellers for each food crop are calculated as a percentage of gross sellers. The percent of net sellers, on average, is higher in the Savane region compared to that in the South Forest region. One possible explanation for this could be that farmers in the South Forest region used their food crops mainly for consumption purposes due to disruptions in food supplies from the north (Figure 7). A majority of farmers in the Savane region sold

their food crops to meet consumption requirements other than food (Figure 5). For simplicity, in Figure 7, we consider five categories of land holding sizes, namely, less than 1 hectare, 1 to 2 hectares, 2 to 5 hectares, 5 to 10 hectares, and more than 10 hectares. The growth of gross and net sellers indicates an upward trend across all farm holding sizes in the Savane. Small and marginal farmers (less than 1 hectare) in the South Forest region remained the only exception. Participation as both a gross and net farmer of food crop declined for farmers with less than 1 hectare of land holding size. For large farmers, positive growth occurred for both types of food crop sellers in this region.

[Figure 6 and 7 are about here]

[Table 2 about here]

In sum, we find a changing pattern of crop choice during the conflict period. This indicates that crop diversification was employed as a coping strategy to achieve self-sufficiency in the face of the conflict. As summarized in Table 2, more than 10% of inhabitants in the South Forest grew only cassava in 2002. However, in 2008, the level of crop diversification in this region matches that of the Savane, which shows a consistent diversification trend between 2002 and 2008.

IV. Theoretical framework

To explain the risk mitigating strategy of farm households on the basis of their crop choices under the threat of conflict, we derive a simple theoretical framework using the excepted value variance (EV) approach following the study of Robinson and Barry (1987), and McNamara and Weiss (2005). Suppose a farm family allocates total available labor, *L*, across *n* different food crops, *i*, and one cash crop enterprise, where

$$L = nl_i + l_0 \qquad (1)$$

assuming that the time allocation for each food crop is similar. Now consider the production technology for the farm's food and cash crops is similar. Furthermore, assume that the technology is a function of labor, offers constant returns to scale, and

is identical for all firms. Hence, in the normal time, output q for food crop i will be $q_i^N = l_i$, and for the cash crop will be $q_0^N = l_0$where superscript N denotes a normal (non-conflict) time.

During periods of conflict, farm households face two correlated risks. First, productivity could decline as the conflict could force the farm households to produce lower output than optimum due to lack of input supplies and the physical risk of operating the farms. Let us denote the actual farm output during the conflict as $q_i^C = \theta l_i$ and $q_0^N = \theta l_0$ where superscript C denotes conflict time, θ is the productivity factor compared with normal times, and $0 \leq \theta \leq 1$.

Now, the expected income of the households in normal times is

$$E^N(y) = \pi^N = p_i l_i + p_0 l_0 - wL - cn \qquad (2)$$

and during times of conflict, this becomes

$$E^C(y) = \pi^C = \theta p_i l_i + \theta p_0 l_0 - wL - cn. \qquad (3)$$

where w is the wage rate of family labor and c is the acquisition cost of each additional food crop farming enterprise, which can also be considered the cost of learning and/or diversification.

The second channel of risk for farm households during conflict arises through the channel of supply chain interruptions. For simplicity, let us assume that this interruption directly causes fluctuations in food crop prices as day-to-day demand–supply nexus for food crops exists. Moreover, food crops are more perishable than cash crops (Barbier, 1989; Parfitt, and Macnaughton, 2010). For simplicity, let us assume that price fluctuations in the food crop market are the source of risk for farms. Assume, for simplicity, that the expected price of all food crops p_i and the variances and covarianc of p_i are identical, which mean, $p_i = p$ and $\sigma_{ii} = \sigma_k^2$, for all $i = 1, \ldots, n$ and $\sigma_{ij} = \rho\sigma_k^2$, for all $i \neq j = 1, \ldots, n$ where ρ denotes the correlation

coefficient, $0 < \rho \leq 1$.[5]

Simplifying equation (3) yields the following:

$$E^C(y) = \pi^C = \theta p\left(\frac{L-l_0}{n}\right) + \theta p_0 l_0 - wL - cn. \quad (4)$$

Now, the certainty equivalent income for this farm household is

$$y_{CE} = E(y) - \frac{\gamma}{2}\sigma^2(y)$$
$$= p\theta(L - l_0) + \theta p_0 l_0 - wL - cn - \frac{\gamma}{2}(L - l_0)^2\sigma_k^2\left[\frac{1+(n-1)\rho}{n}\right]\theta^2. \quad (5)$$

where the degree of risk aversion is $\gamma > 0$.

Maximizing y_{CE} with respect to n will give us the optimal level of food crop diversification by the farm household during times of conflict, which is

$$\frac{\partial y_{CE}}{\partial l_0} = \frac{\theta^2\gamma}{2n^2}(L - l_0)^2(1 - \rho)\sigma_k^2 - c = 0. \quad (6)$$

Hence,

$$n^* = \theta(L - l_0)\sigma_k[\frac{\gamma}{2c}(1 - \rho)]^{\frac{1}{2}}. \quad (7)$$

In terms of optimal degree of food crop diversification, two terms in equation (6) determine the optimal n. Here, the first term of equation (6), which is $\frac{\theta^2\gamma}{2n^2}(L - l_0)^2(1 - \rho)\sigma_k^2 > 0$, represents the gains in the certainty equivalence equation due to reduction in price fluctuation risk of food crop through diversification. This risk reduction comes at a cost of c, which is associated with profits lost due to crop specialization or the cost of acquiring the knowledge/managerial skills needed for diversification. It shows that the smaller the value of c, the larger the diversification will be.

[5] We assumed $0 \leq \rho \leq 1$ during the time of conflict for capturing the covariate shock of conflict on crops.

Equation (7) shows optimum number of crops, n^*, as a function of other model parameters. We perform comparative statics to outline the main theoretical model outcomes.

(i) $\frac{\partial n^*}{\partial \sigma_k} > 0$. This finding suggests that crop diversification is more attractive where the risk of price fluctuations for food crops is substantial. In the context of Cote d'Ivoire, the UN peacekeeping line divided the country into the Savane and the South Forest regions. This conceivably disrupted the food supply chain, thereby increasing food prices. We hypothesize that farm households in the region facing a severe threat of food price fluctuations are much more likely to diversify food crop farming. We consider this an indirect effect of conflict on crop diversification.

(ii) $\frac{\partial n^*}{\partial \rho} < 0$. This condition implies that crop diversification is less attractive in the presence of high correlated shocks. As discussed earlier, ρ is the correlation coefficient, which indicates the risk of correlated shocks during the conflict period. During times of conflict, conditions such as violence, mass protests, and other frequent supply chain interruptions mean that farm households face difficulties in producing any output and as a result, diversification will be lower. We call this a direct effect of conflict on crop diversification.

The comparative statics on the other two parameters yield the following outcomes:

(iii) $\frac{\partial n^*}{\partial \gamma} > 0$. This implies that crop diversification is more attractive for risk-averse farm households.

(iv) $\frac{\partial n^*}{\partial \theta} > 0$. Finally, the effect of θ, which captures farm household productivity during times of conflict, is positive. This implies that farms will be diversifying more if they could achieve higher productivity during the conflict.

V. Empirical outcomes

We use two nationally representative household surveys, one collected in 2002 (before the conflict began) and the other collected in 2008, thus obtaining data that bracket the peak conflict period in Cote d'Ivoire, which lasted from 2002 to 2006. Table 3 displays descriptive evidence for the Savane and the South Forest regions for both 2002 and 2008. While the average welfare level remains higher in the South Forest region than in the Savane, agricultural participation rates increased in both regions during the conflict period. Particularly, in the South Forest region, participation in the cultivation of food crops signficantly increased, as documented previously. Household characteristics are, on average, comparable between the two broad regions identified in this study, with some exception. The Savane is a Muslim-majority area whereas the South Forest is dominated by the Christian population. Participation in non-farm activties is also higher in the South Forest region compared to that in the other region. However, the average area of land cultvated increased in the South Forest region during the conflict period. This indirectly indicates more intense cropping strategies, which partly corroborate the existence of crop diversification.

[Table 3 about here]

A. Indirect Effects of Conflict on Crop Diversification

We first evaluate the indirect effect of conflict on crop diversification. To identify the causal effect of price volatility, we use the UN peacekeeping line that divided the country into the north and the south. Using pre-conflict (ENV-2002 data) data to control for the pre-conflict crop diversification level and spatial variations across the northern region of Savane and the southern region of South Forest, we identify the indirect effect of conflict on post-conflict crop diversification (ENV-2008 data). In order to estimate crop diversification under the risk of supply shocks or price fluctuations, we employed the following multivariate regression model:

$$(8)\ Y_{ijk} = \beta_0 + \beta_1\left(Year_j \times Region_k\right) + \beta_2 Year_j + \beta_3 Region_k + (X_i)\emptyset + \varepsilon_{ijk}$$

where Y_{ijk} is the outcome variable of interest that measures cropping pattern for an individual firm *i* belonging to region *k* in year *j*. Year_j is a dummy variable indicating year fixed effects, and Region_k is a dummy variable that measures region fixed effects. β_1 represents the difference-in-difference estimator, and X_i is a vector of household-specific controls.

Table 4 reports the regression outcomes. Excluding the last column (where the dependent variable measures the number of crops cultivated by a farm household), we show estimated coefificents of probit models. The marginal effects of the key variable, the difference-in-difference indicator, β_1, is shown in the second row (shaded in gray/italics). The first six columns present estimates of the likelihood that a household starts planting a particularly type of crop, such as rice, maize, cassava, yams, plantains, and vegetables during the period between 2002 and 2008. Being a farmer in the South Forest increased the likelihood of cropping rice on average by almost 14 percent during this period, as compared to being a farmer in the Savane. For all crops, excluding plantains, we find increased cultivator numbers in the South Forest region. The growth of yam farmers in the South Forest region was recorded at approximately 20 percent.

[Table 4 is about here]

In columns (7) to (10), we present probit estimates of crop diversification indicators. Column (7) reports the probit estimates for the monocropping practice by household farms, and it appears that after the conflict, the practice of monocropping decreased by 5 percent in the South forest compared with that in Savane, which is statistically significant at the 10 percent level. The practice of bicropping, as reported in column (8), shows a similar tendency, with a 5 percent decrease, though this is statistically insignificant at the conventional level. Our main specification of interest, multicropping practice (a dummy variable that takes the value of 1 if a farm harvests more than two crops within a year and zero otherwise) is depicted in column (9). This indicates that farms are highly likely to have adopted multicropping in the South

Forest area in 2008, which shows evidence suppoting this as a risk reduction stretegy adopted by farms, as demonstrated in our theoretical model ($\frac{\partial n^*}{\partial \sigma_k} > 0$). To put this result into perspective, the likelihood of multicropping being practiced in the South Forest area increased by 19.5 percentage points in 2008 compared with Savane. This finding indicates the changing crop harvesting patterns of the South Forest farmers, who switched from engaging in mono cash cropping to multicropping combining both cash and food crops, as shown in Table 2. Our estimations indicate that this likelihood of changing cultivation pattern to multicropping is posititve and statistically significant. We also verified the same specification again in column (9) with clustering standard errors at the department level and found the estimations to be strictily consistent (not reported). Finally, Column (10) reports the OLS estimation where the dependent variable is number of crops harvested. Consistent with our earlier results, it shows that approximately 7% farmers in the South Forest region increased their number of harvested crops by one additional crop in 2008 compared with farmers in Savane, holding everything else constant.

Consistent with our argument, we see that all farm/agriculture-related occupational houeholds were more likely to adopt multicropping in South Forest in 2008 compared to that in Savane. In addition, we note that personal charactertics of the head as well as household-level observables play significant roles in the likelihood of a household adopting the practice of multicropping, as variables such as household size, household head being male, and land ownership have positive associations with the liklihood of multicropping, whereby years of education has a negative impact. A robust negative coefficent on the South Forest dummy variable implies that crop diversification was higher in Savane in both periods. Similarly, a robust negative coefficient in the year 2008 implies that the overall likelihood of crop production declined due to conflict, which peaked between 2002 and 2008.

B. Direct Effects of Conflict on Crop Diversification

Next, we evaluate the extent of crop diversification as a direct effect of the conflict. In order to estimate crop diversification under correlated shocks, we use variations in conflict intensity across departments. We estimate the following model (equation 9):

$$(9)\ Y_{ijk} = \beta_0 + \beta_1\left(Year_j \times Conflict_k\right) + \beta_2 Year_j + \beta_3 Conflict_k + (X_i)\emptyset + \varepsilon_{ijk}$$

where Y_{ijk} is the outcome variable of interest that measures cropping patterns for a farm housheold *i* that belongs to conflict intensity zone *k* (at department level) in year *j*. Year_j is a dummy variable indicating year fixed effects, Conflict_k is a dummy variable that measures conflict intensity, which take the value of 1 if any conflict event occurs in the relevant department. β_1 is the difference-in-difference estimator, and X_i is a vector of household-specific controls. As mentioned in our theoretical framework in Section IV, crop diversification would be lower in those areas where conflict intensity is higher ($\frac{\partial n^*}{\partial \rho} < 0$) as the conditions for crop diversification are not favourable (due to high *c* or ρ).

[Table 5 is about here]

To capture this empirically, we restricted our sample to households in the South Forest region where crop diversification was found to be higher in 2008 compared with that in Savane, as in the previous subsection. Table 7 provides the regression results of the specification 2 where the dependent variables are cropping choice by farmers in the south region. Our main specification of interest is reported in Column (3) where we see that the year dummy for 2008 is highly statistically significant, which demonstrates the fact that multicropping is highly likely to have increased in the South Forest region in 2008 compared with that in 2002. However, consistent with our theoretical findings, in the high conflict intensity zones, farmers are less likely to engage in multicropping. Our result shows that in 2008, farmers in conflict-affected zones would be approximately 10 percent less likely to adopt multicropping compared with those in the no-conflict zones of the South Forest region. Column (4) reports the same specification as Column (3); however, clustering the standard errors at the department level, our results remain consistent. Column (5) reports the OLS outcome on the number of crops as an alternative measure of crop diversification. Whlie the average number of crops grown is higher in conflict-affected departments, this outcome is not statsitcially significant.

VI. Robustness checks

The regression outcomes for direct and indirect effects of conflict on crop diversification are in line with our theoretical predictions. However, there remain possibilities that undermine these empirical outcomes. It is possible that conflict intensity is higher in departments where crop diversification has been prevalent for years. Moreover, both indirect and direct effects of conflict are identified at the region or department level. As a result, it is possible that the farm-household level regression outcomes are biased by unobservables at the housheold level, as conflict intensities and vulnerability to price volatility of food crop is not measured at the farm-household level. We conduct numerous robustness checks to clarify such doubts.

A. Instrumental variable regressions

As discussed above, the possibility exists that the estimated regression outcomes for the direct and indirect effects shown in Table 4 and 5 could suffer from simultaneous causality bias. To check this possibility, we use a theoretically motivated instrument, a Gini coeffiicent of income at the department level. Dabalen, Kebede, and Paul (2012) show that income inequality is a strong determinant of department-specific conflict events. We find a correlation between income inequality and the interaction term of region and year (identifying the indirect effect) of 0.35, which is statistically significant. Simialrly, a correlation coefficient between income inequality and the interaction term of department and year (identifying the direct effect) is measured at 0.38, which is also statistically significant. The Durbin-Wu-Hausman test yields statistically signficant outcome, indicating that our model suffers from endogeneity issues. Table 6 reports the instrumental variable regression outcomes for both direct and indirect effects of conflict on food crop diversification. As we have one endogeneous variable and one instrument, our model is just identified and the estimation method becomes indirect least squares (ILS). For both indirect and direct effects cases, the instrument is valid and the outcomes are statistically significant (Wald test for IV probit and F test for IV-OLS show satisfactory results). Overall, IV outcomes for direct effects (reported in columns 3 and 4) are in line with priors. For indirect effects, the IV-ILS model outcomes are in line with our findings under OLS

tests. The probability of multicropping actually declines in South Forest under the instrumental variable regresion, however the outcome is not statistically significant.

[Table 6 is about here]

B. Regression outcomes at the aggregate level

We aggregated all the information into 54 observations that are year-region-conflict cohorts at the department level, rather than using individual-level data, recognizing that the key independent variables take only a limited number of possible values. At the department level, we estimate equation 10, as follows:

$$(10)\ Y_{ijk} = \beta_0 + \beta_1(Year_i \times Region_j \times Conflict_k) + \beta_2(Year_i \times Region_j) + \beta_3(Year_i \times Conflict_k) + \beta_4(Region_j \times Conflict_k) + \beta_5 Year_i + \beta_6 Region_j + \beta_7 Conflict_k + (X_i)\emptyset + \varepsilon_{ijk}$$

This framework includes interaction terms as a product of year, region, and conflict intensity variables, which measure the net effect of conflict on food diversification at the aggregate level. As we do not have panel data, i.e., we are not overserving crop diversity for the same farm households over time, these average figures at the department level are the only way to examine the interaction of three different identification strategies. Table 7 reports regression outcomes at the aggregate level. We use average aggregate figures on participation in agriculture, cash crop diversification, and land cultivated as controls. The net effect of conflict on crop diversificatin is positive but not statistically significant. This implies that the indirect effects (price volatility) of conflict marginally dominate the direct effects (vulnerability to conflict events) of conflict at the aggregate level.

[Table 7 is about here]

C. Effects of unobservables

The estimated outcomes from the baseline regressions and robustness tests do not confirm whether the coefficient might be affected by the selection of unobservables. As our next robustness check, we follow the strategy proposed by Altonji, Elder, Conley, and Taber (2005) of using selection on observables to estimate the potential bias from unobservables. Based on this method, we calculate the ratio R= $\frac{\widehat{\beta_{Full}}}{\widehat{\beta_{Restricted}} - \widehat{\beta_{Full}}}$, which indicates how strong the selection on unobservables, relative to selection on observables, needs to be to explain the estimated effect of the full probit or OLS models. Based on various model specifications, this ratio ranges between 2.35 and 34.6, with an average value of 5.43. This implies that the selection on unobservables in our models, on average, need to be approximately five times stronger to explain the estimated coefficients. This confirms that our estimated regression outcomes are less likely to be biased by unobservables.

D. Direct effect using conflict victimization variables

Next, we use nine victimization indicators as potential identifiers of the direct effects of conflict. The ENV-2008, jointly administered by the National Institute of Statistics –Cote d'Ivoire and UNICEF, had a section on the "impact of the war" with a full range of questions to estimate the consequences of conflict on individuals and households. Some example questions include: "how did your income change over the years of crisis?" and "has the current crisis affected your life?" In addition, respondents replied to the following: "have you registered a death or illness linked to the crisis?" and "have you been displaced during the war?" We construct victimization indicators as a dummy variable that takes the value of one for a household or individual being a victim, and zero otherwise. The self-reported victimization indicators may produce subjective bias related to a particular ethnic group or other identities. The simplest way to detect the extent of this bias is to estimate each victimization indicator as a function of the observable characteristics. We do not find any bias specific to such household or individual characteristics. The probit outcomes on the probability of multi-cropping as a function of such

victimization indicators are reported in Table 8. Identification of the direct effects of conflict in terms of victimization variables show dampening effect on multi-cropping; this is similar to our findings through variation in the conflict intensity across departments. The outcomes are statistically significant when direct effects are measured as household members affected by war and having experienced violence during the conflict.

[Table 8 is about here]

E. Falsification test: Cash crop diversification facing conflict

Our theoretical model predicts that the indirect effects of conflict result only in intense crop diversification as a coping strategy households adopt when facing protracted crisis. We provide robust empirical support to this model. However, it is also possible that households mitigate risk by intensifying cash crops given the rich history of cocoa, coffee, and rubber cultivation in Cote d'Ivoire. In the presence of such actions, the food crop diversity resulting from conflict is confounded. We test this possibility by considering cash crop diversification. We construct a cash crop variable including households involved in growing cocoa, coffee, cotton, rubber, and palm. Table 9 shows empirical estimates of cash crop diversification due to both direct and indirect effects of the conflict. The direct effects or the covariates shocks of conflict are negative on cash crop diversification, which is similar to our findings for food crop. However, the indirect effects or the effect through the interruption of the food supply chain also lowers cash crop diversification. Thus, we can reject the possibility that cash crops were also a coping mechanism for households facing conflict.

[Table 9 is about here]

VII. Effects of conflict on crop diversification: Identifying channels

In the previous sections, the importance of crop diversification is highlighted through

investigations of the distortions to agricultural incentives provided mostly through rising prices of food commodities and direct victimization caused by Cote d'Ivoire's civil conflict. While the indirect effect of conflict is significant in the South Forest region, it deserves some discussion in terms of the possible channels through which crop diversificatin might lead to possible welfare benefits. Below, we consider several ways to look at these issues.

A. Increasing vulnerability to poverty

To measure the direction and magnitude of the welfare consequences of a price change, we compare non-parametric probability regressions over time. A more direct way of estimating the changing risk of poverty among farmers is to plot the probability of being a multi-cropper along the welfare distribution (Benjamin and Deaton, 1993). This is conducted using the probability regression method where the proportion of multi-cropping farmers is estimated as a function of per capita household expenditure. The left hand panel of Figure 8 compares probability of being a multi-cropper estimated as a function of log per capita household consumption expenditures for the Savane region. In 2002, for farm households below the poverty line [estimated at log per capita household consumption expenditures equivalent to 4.8, from Dabalen and Paul (2013)], approximately 70 percent were engaged in multi-cropping, which declined by approximately 10 percentage points in 2008 in the Savane. For those above the poverty line, the results show a similar picture. On the other hand, in the South Forest region, between 2002 and 2008, the probability of a multi-cropper being below the poverty line increased almost three folds. However, for rich farm households, an opposite picture emerges. Overall, these findings suggest that in the South Forest region, the association between vulnerability and multi-cropping became stronger, unlike in the Savane region.

[Figure 8 is about here]

B. Increasing vulnerability to food insecurity

To examine poverty in relation to food insecurity, we use a proxy measure of food

security, namely food consumption scores (FCS)[6] developed by the World Food Programme (WFP, 2007). FCS measures calorie availability from food consumption considering both food diversity and the frequency of food intake[7]. FCS is calculated using the frequency of consumption of eight food groups consumed by a household over the past seven days as reported in the survey. Based on this index, we construct a dummy variable for a food-secured household if the FCS is above 35, which shows the acceptable level of food security (WFP, 2007). Table 10 reports regression outcomes of direct and indirect effects of conflict on food security. On average, the direct effects of conflict lower food security. The indirect effect also shows similar outcomes, but these are not statistically significant. This could imply that food security remains an issue for those households indirectly affected by conflict, but to a lesser extent due to their crop diversification strategies.

[Table 10 is about here]

VIII. Conclusion

This study contributes to a burgeoning literature on the strategies that households utilize to cope with the risks presented by civil conflict. We consider the Ivoirian conflict that peaked in the 2002–2004 period. The main motivation comes from the fact that during the period of heightened tension due to conflict, the north–south divide imposed by the UN peacekeeping line disrupted the agricultural supply chain. While cocoa and coffee are produced mainly in the rainforests in the south, cereals and other food crops are mostly produced in the northern Savane region. We build a theoretical model based on the premise that farm households opt for crop diversification to achieve food self-sufficiency in the face of price fluctuations (or indirect shocks) due to this disruption of food supply chain. On the other hand, we also consider covariate shocks (or direct effects) that negatively affect crop diversification. We find robust and statistically significant outcomes supporting such

[6] The FCS is a frequency-weighted diet diversity score, also referred to as a “food frequency indicator.” (WFP, 2007).
[7] This is based on the earlier work by Ruel (2002) and Hoddinott and Yohannes (2002).

claims. The baseline outcomes withstand a series of robustness checks. Overall, the net effect of conflict on crop diversification is positive but not statistically significant. We also find that increasing vulnerability to poverty and food insecurity during conflict seems to be the underlying factors that motivate farm households to adopt such coping strategies.

During periods of conflict, poilitical decisions are unpredictable and, when viewed in light of history, sometimes irrational as well. Thus, it is not surprising that for commodities in Cote d'Ivoire, government-imposed distortions created a gap between domestic prices and those potentially available in free market conditions (Abbott, 2007; Abbott, 2009). However, Chauveau & Richards (2008) reveal that the youth militia were motivated to be involved in the civil conflict to uphold a lineage-based social order to maintain agrarian ownership. This suggests that unlike in other economies, the coping strategies that a household could utilize were discriminated against, as with militia ownership of land, crop diversification would not be an option that everyone could implement. Thus, agrarian issues in Cote d'Ivoire are more complex than initially perceived, as other studies indicate (Ajayi, Akinnifesi, Sileshi, & Ajayi, 2009; Auty, 2010). Nevertheless, we hope that this study is a step to unfold this complex picture and draft a sound policy framework.

References

Abbott, P. (2007). Distortions to agricultural incentives in Côte d'Ivoire. *World Bank Agricultural Distortions Working Paper No. 46*.

Abbott, P. (2009). Cote d'Ivoire. In K. Anderson & W. A. Masters (Eds.), *Distortions to Agricultural Incentives in Africa* (pp. 385-412). Washington D.C.: World Bank Publications.

Arias, M. A., Ibáñez, A. M., & Zambrano, A. (2013). Agricultural Production amidst Conflict: The Effects of Shocks, Uncertainty and Governance of Non-State Armed Actors. (Working paper, Universidad de los Andes).

Barbier, Edward (1989) Cash crops, food crops, and sustainability: The case of Indonesia, World Development.

Brück, Tilman. (2004). The Welfare Effects of Farm Household Activity Choices in Post-War Mozambique. DIW Berlin Discussion Papers No. 413.

Brück, T., & Schindler, K. (2008). The Impact of Conflict and Fragility on Households: A Conceptual Framework with Reference to Widows. *UNU-WIDER Working Paper Series - Research Paper No. 2008/83*

Bundervoet, Tom. 2007 "Livestock, Activity Choices and Conflict: Evidence From Burundi" Households in Conflict Network Working Paper No. 24.

Chauveau, J. P., & Richards, P. (2008). West African insurgencies in agrarian perspective: Côte d'Ivoire and Sierra Leone compared. *Journal of Agrarian Change, 8*(4), 515-552

Dabalen, Andrew and Saumik Paul (2014) "Effect of Conflict on Dietary Energy Supply: Evidence from Cote d'Ivoire" (2014) *World Development,* 58, 143-158.

Dabalen, Andrew and Saumik Paul (2013) "Recovering Comparable Poverty Estimates in Cote d'Ivoire" (2013) *Journal of Development Studies* 49 (10), 1412-1426.

Dabalen, Andrew, E. Kebede and Saumik Paul (2012) "Causes of Civil War: Micro-level Evidence from Cote d'Ivoire" (2012) *HiCN Working Paper 118.*

Flores, M. (2004). Conflicts, rural development and food security in West Africa. ESA Working Paper No. 04-02, January, Rome

Hitzhusen, F. J., & Jeanty, P. W. (2006). Analyzing the effects of conflicts on food security in developing countries: An instrumental variable panel data approach. 2006 Annual meeting, July 23–26, Long Beach,
CA 21483, American Agricultural Economics Association

McNamara, Kevin T, & Weiss, Christoph. (2005). Farm household income and on-and

off-farm diversification. *Journal of Agricultural and Applied Economics, 37*(1), 37-48.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 3065-3081.

Robinson, L.J., and P.J. Barry (1987), "The Competitive Firm's response to Risk. London: MacMillan Publishing Company.

Rockmore, M. 2012. "Living Within Conflicts: Risk of Violence and Livelihood Portfolios" Households in Conflict Working Paper No. 121.

Sany, J., (2010). USIP special report. United States Institute of Peace.

Taeb, M. (2004). Agriculture for peace: Promoting agricultural development in support of peace. Japan: United Nations University-Institute of Advanced Studies.

Townsend, R. M. (1995). Consumption insurance: An evaluation of risk-bearing systems in low-income economies. *The Journal of Economic Perspectives, 9*(3), 83-102

Verpoorten, M. (2009). "Household Coping in War and Peacetime: Cattle Sales in Rwanda, 1991- 2001." Journal of Development Economics 88(1): 67 - 86.

Vlassenroot, Koen (2008) "*Land Tenure, Conflict and Household Strategies in the Eastern Democratic Republic of the Congo*" in eds. Alinovi, Luca, Günter Hemrich, and Luca Russo. Food Security in Protracted Crises.

World Food Programme (WFP). (2007). Food consumption analysis: Calculation and use of the food consumption score in food consumption and food security analysis. Technical Guidance Sheet (draft). Rome: World Food Programme.

WFP (2008). Assistance to populations affected by the Coˆte d'Ivoire protracted crisis – Protracted relief and recovery operations (PRRO) 10672.0 report. Rome: World Food Programme.

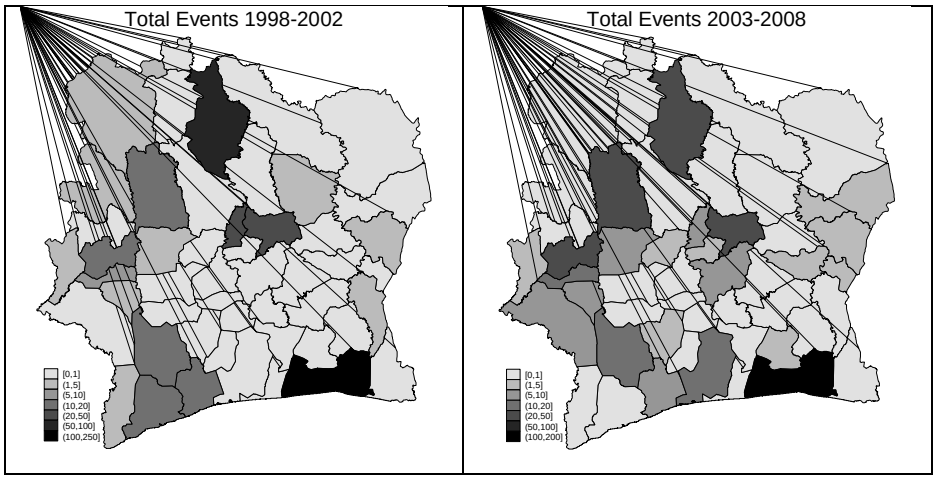
Figure 1 The ‘UN Peace Belt’ dividing Cote d’Ivoire into two parts

Source: http://www.globalsecurity.org/military/world/war/ivory-coast-2002.htm

Figure 2 Incidence of Conflict in Cote d'Ivoire: 1997 to 2010

Source: Authors' calculation based on the ACLED database

Figure 3 Conflict Events from 1998 to 2008 by departments



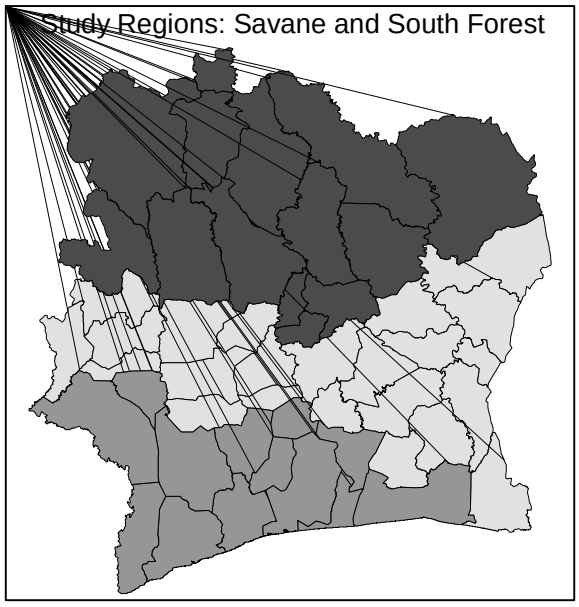
Source: ACLED and authors own calculations

Table 1 Descriptive statistics of conflict counts at department/ sub-prefecture level

Level	Total events	Obs.	Mean	Std. Dev.	Min	Max	Zeros (%)
Department	1999-2002	50	9.16	32.73	0	223	44%
	2003-2006	50	8.58	24.78	0	169	26%

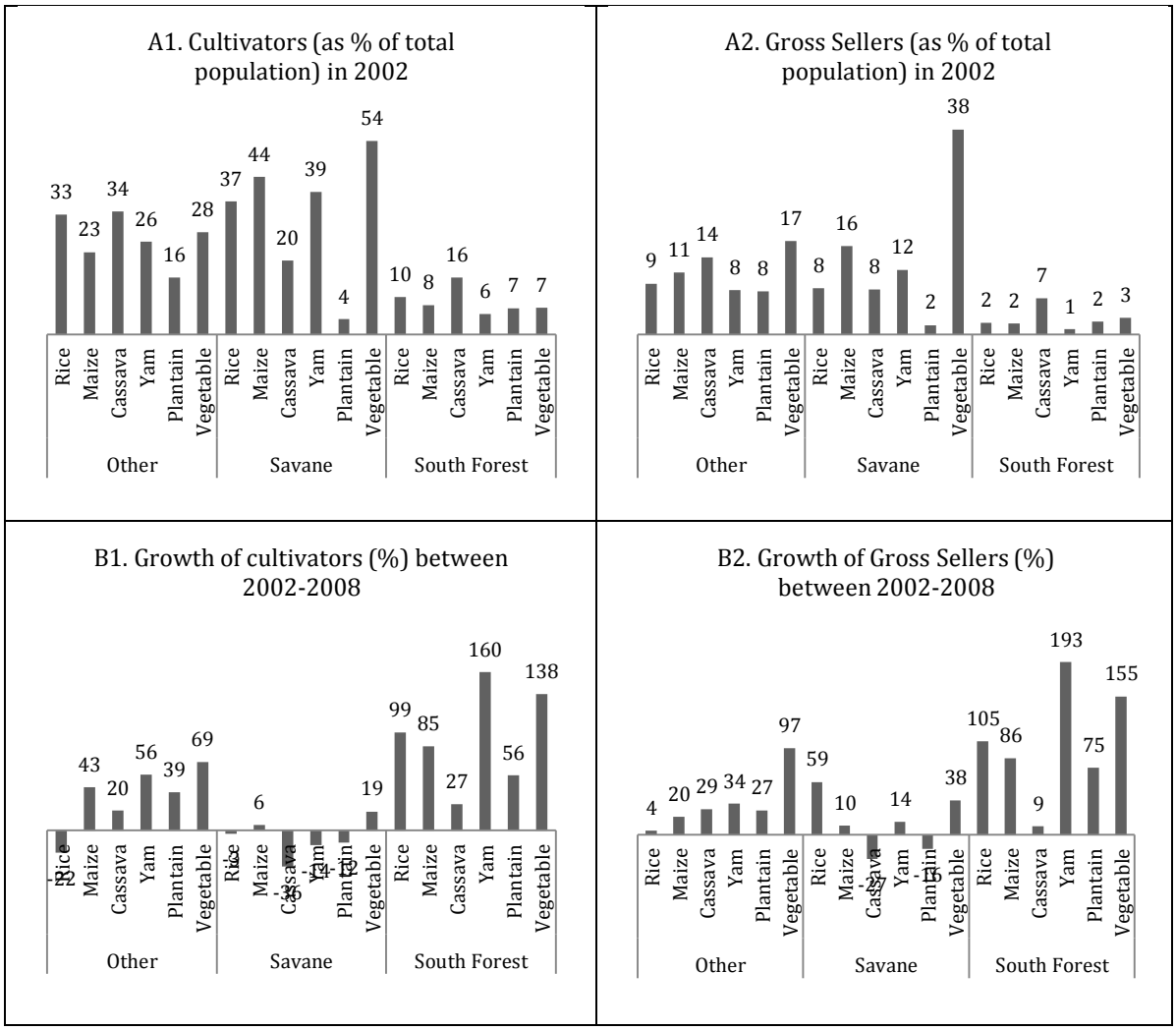
Source: ACLED and authors' calculation

Figure 4: Study areas



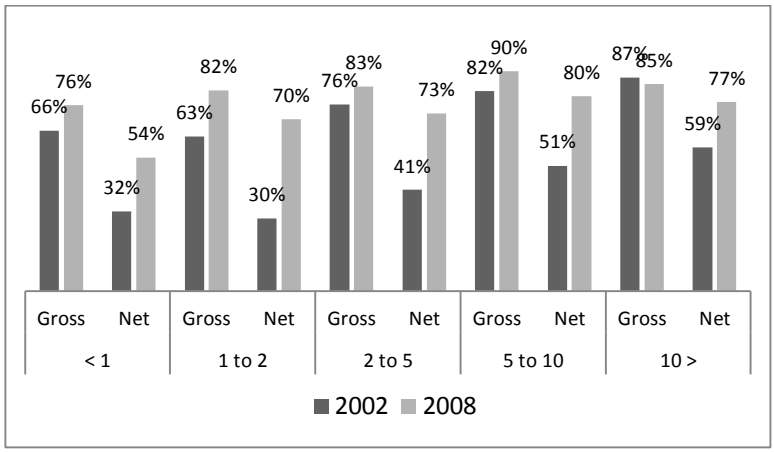
Note: Savanna (darker shade), South Forest (dark shade)
Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Figure 5 Gross sellers between 2002 and 2008



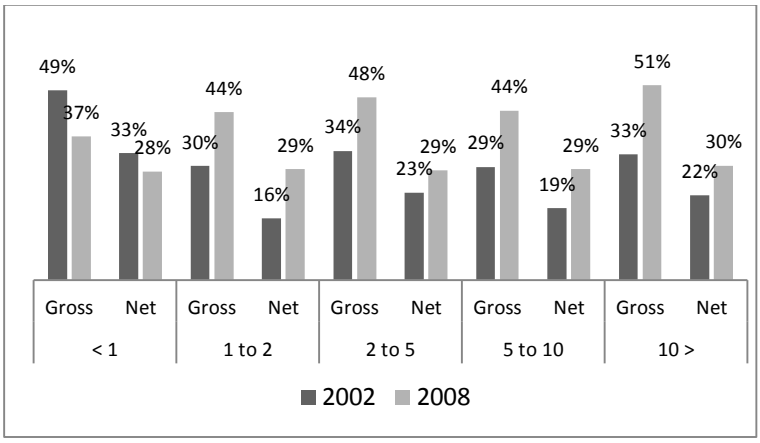
Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Figure 6 Gross and Net Sellers by farm holding Size (in hectares) in Savanna



Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Figure 7 Gross and Net Sellers by Farm holding Size (in hectares) in South Forest



Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Table 2 Food crops (with more than 10% of population cultivating it) before and after the Conflict

	Savanna	South Forest
Pre-war crops (2002)	Rice Maize Cassava Yam Vegetables	Cassava
Post-war crops (2008)	Rice Maize Cassava Yam Vegetables	Rice Maize Cassava Yam Plantain Vegetables

Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Table 3 Descriptive Statistics

	2002				2008			
	Savanna		South Forest		Savanna		South Forest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Rice cropper	0.32	0.47	0.10	0.30	0.25	0.44	0.15	0.35
Maize cropper	0.40	0.49	0.07	0.25	0.33	0.47	0.11	0.31
Cassava cropper	0.18	0.38	0.13	0.34	0.11	0.31	0.14	0.35
Yam cropper	0.34	0.47	0.04	0.20	0.25	0.43	0.09	0.29
Plantain cropper	0.03	0.16	0.06	0.23	0.03	0.16	0.08	0.27
Palm cropper	0.00	0.04	0.03	0.17	0.00	0.06	0.02	0.15
Vegetables cropper	0.52	0.50	0.07	0.25	0.50	0.50	0.12	0.32
Fruits cropper	0.03	0.17	0.01	0.11	0.05	0.23	0.02	0.15
Cocoa farmer	0.01	0.08	0.20	0.40	0.01	0.12	0.23	0.42
Coffee farmer	0.01	0.10	0.11	0.31	0.01	0.11	0.09	0.28
Cotton farmer	0.20	0.40	0.00	0.00	0.05	0.22	0.00	0.00
Rubber farmer	0.00	0.04	0.03	0.17	0.00	0.00	0.04	0.21
Agricultural households	0.62	0.49	0.32	0.47	0.58	0.49	0.35	0.48
Participation in agriculture	0.60	0.49	0.30	0.46	0.66	0.47	0.48	0.50
Participation in livestock	0.28	0.45	0.11	0.31	0.32	0.47	0.13	0.33
Participation in wage	0.22	0.41	0.42	0.49	0.29	0.45	0.49	0.50
Participation in livelihood (other)	0.10	0.30	0.12	0.32	0.13	0.34	0.20	0.40
HH size	5.96	4.24	5.20	3.62	4.90	3.32	4.92	3.38
Children below 4 years	0.88	1.06	0.71	0.94	0.74	0.96	0.70	0.91
Children between 5 and 9 years	0.97	1.19	0.65	0.93	0.70	0.98	0.63	0.89
Education of HH head (years)	2.35	4.49	5.47	5.81	1.78	3.76	5.39	5.23
Average education of HH (years)	1.88	3.02	4.00	3.79	1.51	2.56	4.07	3.56
Age of HH head	44.37	14.61	41.73	13.21	44.13	14.58	41.46	12.95
Male HH head	0.86	0.35	0.83	0.38	0.79	0.41	0.82	0.38
Married HH head	0.78	0.41	0.70	0.46	0.74	0.44	0.72	0.45
Christian	0.15	0.35	0.51	0.50	0.13	0.33	0.47	0.50
Muslim	0.62	0.49	0.36	0.48	0.66	0.47	0.37	0.48
Land owned (hectares)	11.33	31.04	7.25	11.96	10.43	23.52	10.59	24.05
Land cultivated (hectares)	7.97	28.87	5.13	9.65	7.34	22.07	7.86	22.61
Land fallowed (hectares)	6.65	12.18	4.68	7.05	5.86	8.87	5.45	8.90
Food secured	0.79	0.41	0.61	0.49	0.34	0.47	0.51	0.50
Log of per capita HH expenditure	5.03	0.33	5.15	0.37	4.97	0.37	5.17	0.34

Table 4: Prevalence of multi-cropping before and after the conflict peak: Probit and OLS outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable: Crop Choice	**Rice**	**Maize**	**Cassava**	**Yam**	**Plantain**	**Vegetables**	**Mono-Cropper**	**Bi-Cropper**	**Multi-Cropper**	**Crop Diversification**
South Forest x Year(2008)	0.683***	0.755***	0.370**	1.073***	-0.340	1.009***	-0.264*	-0.225	0.835***	0.732***
Marginal Effect	*0.138*	*0.167*	*0.102*	*0.208*	*-0.033*	*0.209*	*-0.048*	*-0.054*	*0.195*	
Year Dummy (if Year 2008)	-0.326***	-0.533***	-0.332***	-0.631***	0.376	-0.706***	0.035	-0.014	-0.503***	-0.444***
South Forest Dummy	-0.238	-1.012***	0.206	-1.274***	1.242***	-1.965***	0.669***	0.073	-1.019***	-1.075***
Occupation: Farmer (any crop)	1.957***	2.512***	1.345***	2.266***	0.651***	2.689***	1.078***	1.573***	2.175***	1.896***
Occupation: Livestock Production	0.335***	0.283***	0.142***	0.235***	0.171***	0.336***	-0.073	-0.026	0.344***	0.410***
Occupation: Wage Employment	-0.016	0.032	-0.036	-0.060	-0.089	-0.133***	0.053	0.026	-0.124***	-0.086***
Occupation: Other Income Sources	-0.075	0.213***	0.034	0.009	0.064	0.116**	-0.022	-0.110**	0.168***	0.077*
Size of the Household	0.045***	0.036***	0.015*	0.022**	-0.008	0.024***	-0.018*	-0.004	0.038***	0.033***
Years of Education: head of HH	0.003	-0.004	-0.003	-0.018*	-0.010	-0.013	0.009	0.011	-0.017**	-0.015***
Age of HH head	-0.002*	-0.002	0.004***	0.001	-0.001	0.001	0.000	-0.001	0.001	0.000
Male HH head (dummy)	0.119*	0.239***	-0.272***	0.441***	-0.043	-0.114*	-0.221***	-0.147**	0.181***	0.081**
Head of HH married	0.135**	0.110*	0.049	-0.019	0.252***	0.201***	-0.044	0.128**	0.098*	0.149***
Land cultivated (in hectares)	-0.011***	-0.002	0.001	-0.005	-0.012***	-0.004	-0.005	-0.001	-0.005	-0.009***
Land owned (in hectares)	0.013***	0.005*	0.001	0.008***	0.013***	0.005	-0.004	0.000	0.010***	0.013***
Number of observations	7,437	7,437	7,423	7,404	6,040	7,437	7,360	7,456	7,437	7,456
Pseudo R Square/ R square	0.327	0.352	0.297	0.393	0.317	0.435	0.176	0.131	0.315	0.495

All models include department fixed effects; Year takes the value of 1 if 2008, 0 if 2002; Region takes the value of 1 if South Forest, 0 if Savane
The last column shows OLS outcomes; the rest of the columns show probit outcomes; Robust standard errors (.01 - ***; .05 - **; .1 - *) / Clustered standard errors produce less significant outcomes except for column 10 specification; Household controls include: Participation in crop production, participation in livestock production, participation in wage employment, participation in other income sources, household size, Number of children below 5 years, Number of children from 5 to 9 years, Years of education of head of HH, Average years of education in the HH, Age of head of HH, Gender of head of HH, Muslim HH, Christian HH, Land owned (in hectares), Land cultivated (in hectares), Ethnic groups (Akan, Krou, Mande north, Mande south and Voltaic)

Table 5: Prevalence of multi-cropping and the intensity of conflict in the South Forest region, Probit and OLS outcomes

	(1)	(2)	(3)	(4)	(5)
	Mono-Cropper	**Bi-Cropper**	**Multi-Cropper**	**Multi-Cropper#**	**Food Crops**
Conflict x Year (2008)	0.176	-0.210	-3.707***	-3.707***	0.048
Marginal Effects	0.054	-0.057	-0.961	-0.961	--
Year Dummy (if Year 2008)	-0.307	0.022	3.967***	3.967***	0.223
Conflict Dummy	0.140	-0.083	3.523***	3.523***	-0.546
Occupation: Farmer (any crop)	-0.028	0.261	0.557***	0.557	0.531***
Occupation: Livestock Production	-0.096	0.045	0.334***	0.334***	0.455***
Occupation: Wage Employment	0.039	0.104	-0.143**	-0.143*	-0.103
Occupation: Other Income Sources	-0.049	-0.169**	0.201***	0.201**	0.142*
Size of the Household	-0.012	0.003	0.034**	0.034*	0.044***
Years of Education: head of HH	0.006	0.005	-0.010	-0.010	-0.015
Age of HH head	0.001	-0.004*	0.001	0.001	-0.002
Male HH head (dummy)	-0.250**	-0.348***	0.013	0.013	-0.237**
Land cultivated (in hectares)	-0.005	-0.002	-0.002	-0.002	-0.004
Land owned (in hectares)	-0.004	0.004	0.006	0.006	0.008**
Number of observations	**2,822**	**2,813**	**2,803**	**2,803**	**2,822**
Pseudo R Square/ R square	**0.076**	**0.045**	**0.156**	**0.235**	**0.235**

Notes: Robust standard errors clustered at the individual level except for column 4 where standard errors are clustered at the department level (marked as #). Standard errors significant at the 10% (*), 5% (**), and 1% (***). All the Regression controls for ethnic groups (Akan, Krou, Mande North, Mande South and Voltaic), number of children below 5 years, number of children from 5 to 9 years, marital status of the head of the household, average years of HH education, Head's religious affiliation, marital status and department fixed effects. The last column of the table reports OLS regression, the rest of the columns show Probit outcomes. Conflict intensity takes the value of 1if there is any conflict event), zero otherwise.

Table 6: Instrumental Variable regression outcomes

	Indirect Effect		Direct Effect	
	Multi-Cropper	Food Crops	Multi-Cropper	Food Crops
	IV-Probit	IV-ILS	IV-Probit	IV-ILS
	(1)	(2)	(3)	(4)
Second stage outcomes (Dependent variable: Crop Diversification)				
South Forest x Year (2008)	**-0.499**	**6.004*** **		
South Forest dummy	-0.226	-3.719***		
Year (2008) dummy	0.127	-2.341***	13.239***	51.181***
Conflict x Year (2008)			**-13.365*** **	**-51.828*** **
Conflict dummy			12.889***	49.756***
Constant	-4.193***	1.740***	-13.666***	-45.927**
Wald chi2	1414.29		781.48	
F -test		153.15		9.65
First stage outcomes (dependent variable: South Forest * Year)				
Gini Coefficient of income	2.433***	-0.26***	0.052***	0.051**
Year dummy	0.365***	0.38***	0.976***	0.976***
South Forest dummy	0.588***	0.54***		
Conflict dummy			0.957***	0.957***
Constant	-1.593***	-0.12***	-0.974***	-0.926***
Wald Chi2	7.25		21.48	
F-test		585.77		6450.47
Number of observations	7,437	7,456	2,822	2,822

Notes: Robust standard errors significant at the 10% (*), 5% (**), and 1% (***). All the Regression controls for ethnic groups (Akan, Krou, Mande North, Mande South and Voltaic), number of children below 5 years, number of children from 5 to 9 years, marital status of the head of the household, average years of HH education, Head's religious affiliation, marital status and department fixed effects. Conflict intensity takes the value of 1if there is any conflict event), zero otherwise.

Table 7: The Effects of Conflict on Crop Diversification at the aggregate (department) level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Rice	Maize	Cassava	Yam	Plantain	Vegetables	Mono-Cropper	Bi-Cropper	Multi-Cropper	Crop Diversification
Year (2008) x Conflict x Region	-0.101	0.197	-0.069	0.2	0.121	-0.157*	-0.138	0.045	0.15	0.439
Year (2008)	-0.155	-0.022	-0.1	-0.185	0.058	0.016	0.03	0.071	-0.128	-0.417
Conflict	-0.08	0.127	-0.109	-0.139	-0.076	0.003	0.031	0.064*	-0.112	-0.31
Region	-0.172	-0.064	0.017	0.033	0.077	0.023	0.055	0.003	-0.068	-0.119
Year x Region	0.103	-0.087	0.037	-0.109	-0.169	0.144*	0.11	-0.026	-0.102	-0.249
Region x Conflict	0.138	-0.207*	0.113	-0.102	-0.016	0.01	0.033	-0.037	-0.059	-0.29
Year x Conflict	0.096	-0.11	0.12	0.174	0	0.012	-0.005	-0.081	0.106	0.327
R2	0.398	0.445	0.349	0.645	0.357	0.251	0.163	0.473	0.689	0.785

Note: All models show OLS outcomes; Robust standard errors. Standard errors significant at the 10% (*), 5% (**), and 1% (***). Controls include: Participation in agriculture, cash crop diversification and land cultivated. Each regression model has 56 observations.

Table 8: Direct Effects of Conflict on Crop Diversity using Conflict Victimization variables

Dependent variable: Multi-cropper dummy									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Registered deaths	-0.088								
Registered injury		-0.077							
Had to hide			-0.133						
Lost ownership				-0.110					
Displaced					-0.32***				
Lost job						-0.039			
Lost assets							-0.036		
Affected by the war								-0.29***	
Experienced violence									-0.246**
Constant	-1.82***	-1.76***	-1.78***	-1.82***	-1.77***	-1.84***	-1.83***	-1.66***	-1.80***
Observations	1,505	1,489	1,520	1,520	1,520	1,520	1,520	1,520	1,520

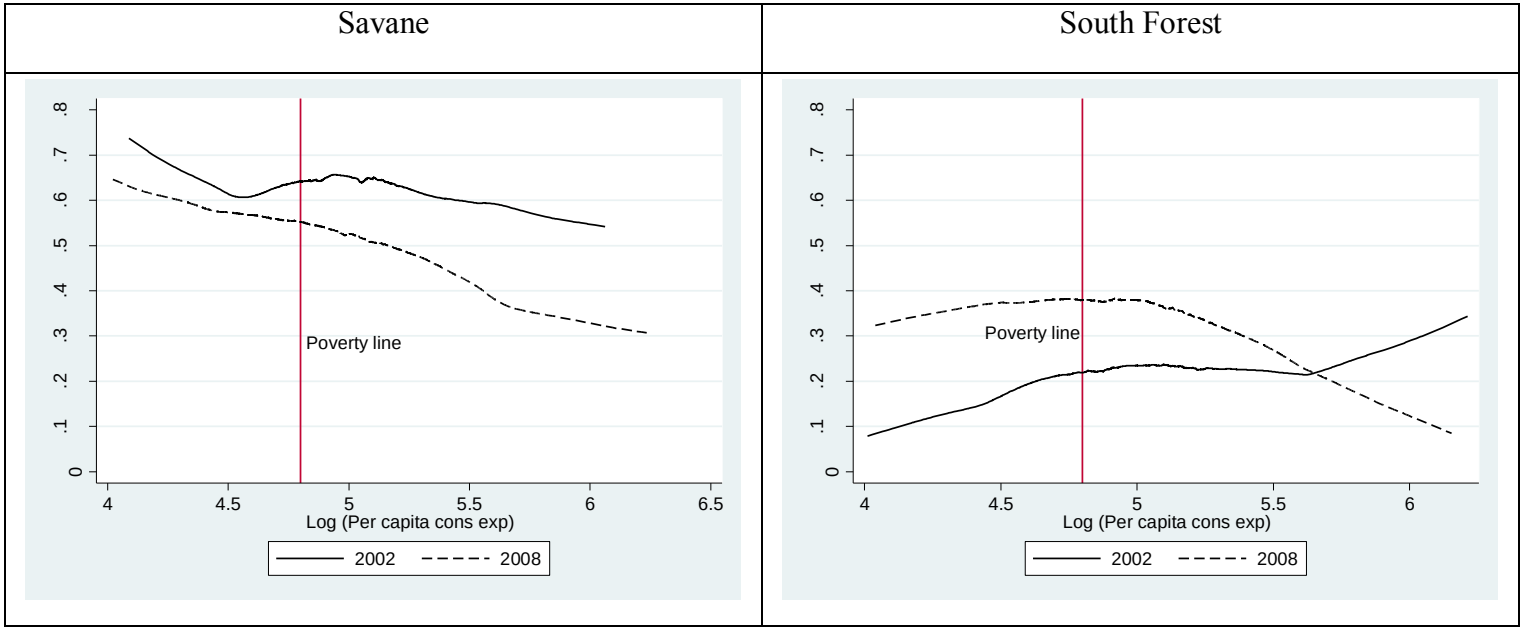
Notes: Robust standard errors significant at the 10% (*), 5% (**), and 1% (***). All the Regression controls for ethnic groups (Akan, Krou, Mande North, Mande South and Voltaic), number of children below 5 years, number of children from 5 to 9 years, marital status of the head of the household, average years of HH education, Head's religious affiliation, marital status and department fixed effects. All models show Probit outcomes.

Table 9: Likelihood of Cash Crop Diversification facing conflict

	Indirect Effects		Direct Effects	
	Multi-Cropper	Cash Crops	Multi-Cropper	Cash Crops
	(1)	(2)	(3)	(4)
South Forest x Year (2008)	-0.858**	-0.035		
Year Dummy (if Year 2008)	0.581*	0.034	4.302***	0.342***
South Forest dummy	1.965***	0.716***		
Conflict x Year (2008)			-4.731***	-0.483***
Conflict dummy			4.580***	0.149**
Constant	-4.730***	-0.328***	-7.191***	-0.602***
Number of observations	6,119	7,456	2,803	2,822

Notes: Robust standard errors significant at the 10% (*), 5% (**), and 1% (***). All the Regression controls for ethnic groups (Akan, Krou, Mande North, Mande South and Voltaic), number of children below 5 years, number of children from 5 to 9 years, marital status of the head of the household, average years of HH education, Head's religious affiliation, marital status and department fixed effects. Conflict intensity takes the value of 1if there is any conflict event), zero otherwise.

Figure 8 Non-parametric estimation of the fraction of multi-croppers on a poverty scale



Source: Authors' own calculation based on the ENV 2002 and ENV 2008

Table 10: Vulnerability to Food security during conflict

	Indirect effects	Direct effects							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
South Forest * Year (2008)	-0.153								
Year (2008) dummy	-0.982***	-0.772***							
South Forest dummy	-0.388***								
Conflict * Year (2008)		-0.472							
Conflict dummy		0.923***							
Registered deaths			-0.235**						
Registered injury				-0.163					
Had to hide					-0.078				
Lost ownership						-0.192*			
Displaced							-0.100		
Lost job								-0.054	
Lost assets									-0.293*
Constant	0.944***	-1.191***	-0.849*	-0.858*	-0.904**	-0.905**	-0.888**	-0.898**	-1.040**
Number of observations	7,373	2,730	1,505	1,489	1,520	1,520	1,520	1,520	1,520
Pseudo-R2	0.23	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Notes: Robust standard errors significant at the 10% (*), 5% (**), and 1% (***). All the Regression controls for ethnic groups (Akan, Krou, Mande North, Mande South and Voltaic), number of children below 5 years, number of children from 5 to 9 years, marital status of the head of the household, average years of HH education, Head's religious affiliation, marital status and department fixed effects. Conflict intensity takes the value of 1if there is any conflict event), zero otherwise.