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Farming or Fighting? Agricultural Price Shocks and Civil War in Africa

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Summary. — This article links lower economic returns in the labor-intensive agricultural sector to a higher risk of armed conflict at the local level. It argues that income shocks, followed by rising unemployment and lower wages in the rural economy, facilitate rebel recruitment and strengthen civilian support for rebel movements. Focusing on Africa, the article introduces a location-specific measure of changes to the value of local agricultural output by combining sub-national crop production maps with data on movements in global agricultural prices. The results show that negative changes to the local agricultural price index significantly and substantially increase the risk of violent events.

Key words — economic shocks, income shocks, agricultural prices, civil war, armed conflict

1. INTRODUCTION

The association between low or negative economic growth and civil war is one of the most consistent and robust findings in the research on civil war (e.g., Collier & Hoeffler, 2004; Hegre & Sambanis, 2006). It is supported by one of the most influential economic theories of conflict holding that falling income increases individual incentives to join a rebellion by lowering opportunity costs (Bazzi & Blattman, 2014; Collier & Hoeffler, 2004; Grossman, 1991; Hirshleifer, 1995).[1] Yet, the relationship remains theoretically and empirically ambiguous. Recent studies, which attempt to address the bias arising from omitted variables and reverse causality in conventional growth-conflict regressions, report inconsistent findings (c.f., Besley & Persson, 2008; Bazzi & Blattman, 2014; Brückner & Ciccone, 2010; Miguel, Satyanath, & Serengeti, 2004). Scholars thus disagree whether falling income heightens conflict risk by increasing labor supply to rebel groups, or, to the contrary, dampens conflict risk by decreasing the economic pay-offs from violent predation and state capture (c.f., Besley & Persson, 2008).

The inconclusive findings suggest that the effects of income fluctuations could be heterogeneous across different economic sectors and areas of society. Yet, current research often ignores this heterogeneity. The conventional cross-national growth-conflict regressions not only conflate potentially diverging effects, but also mask the channel through which falling income influences conflict risk. At this level of aggregation alternative mechanisms, such as weakening state capacity, are observationally equivalent to the opportunity-cost mechanism. This leaves crucial research questions unanswered related to when and how income shocks increase individual incentives to partake in civil war violence. The opportunity-cost mechanism should primarily be triggered by income fluctuations that affect household poverty and economic opportunities at the local level. Addressing these questions thus requires situating the consequences of the specific income shocks in the context where they occur and requires more disaggregated research designs that allow for the identification of the mechanism at the level where it unfolds.

Addressing this gap, this article examines how income fluctuations in the labor-intensive agricultural sector influence the risk of civil war violence at the local level. It outlines an argument linking negative changes in the value of local agricultural output to higher incentives among the rural population to join rebel organizations and to support the rebels' radical agendas. I argue that what primarily drives this mechanism are the lower opportunity costs following raising unemployment and lower wages for peasants and wage-laborers in the rural economy, but may also be reinforced by the decreasing ability of the state to placate the peasantry at a time when state revenue from the agricultural sector drops.

To evaluate the relationship between local income shocks and violent conflict the empirical analysis combines sub-national, time-invariant, crop-production maps with information on movements in global agricultural prices to construct a location-specific and arguably exogenous measure of changes to the value of local agricultural output. The analysis relies on a grid structure that divides the African continent into sub-national units of 0.5×0.5 degrees (approximately 55×55 km at the equator) and utilizes geo-referenced event data on civil war violence between 1990 and 2010 from the Uppsala Conflict Data Program (UCDP) (Sundberg & Melander, 2013). The results show that changes to the local agricultural price index have considerable explanatory power in predicting the timing and location of violence at the local level. The negative relationship between the agricultural price index and the risk of violence is robust across a range of different statistical

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estimators, different model specifications and alternative operationalizations of independent and dependent variables.

These findings suggest a link between economic frustrations and individual incentives to directly partake in or support a rebellion. I find no evidence that increasing value of economic output in the agricultural sector precipitates violence through a rapacity effect. These findings also enhance our understanding of the particular channels through which worsening economic conditions heighten the risk of civil war by, at least partly, discriminating between the opportunity-cost mechanism and the effect of a weakened military and security apparatus. Agricultural price shocks could arguably reduce state counter-insurgency capacity as revenue from agricultural export and taxation falls, thus placing constraints on military spending. Yet, a lower ability to suppress insurgency should arguably not be conditioned on the local patterns of agricultural production in the way the results from this analysis suggest. The results thus favor the opportunity-cost explanation over the state capacity explanation linking local income shocks to a higher risk of armed conflict.

The article is organized as follows. I begin Section 2 by briefly reviewing the existing literature on negative or low economic growth and armed conflict to clarify the motivation behind my own approach. Section 3 outlines a theoretical mechanism specifically linking negative shocks in the rural economy to a higher risk of conflict violence. Section 4 introduces the research design and the data, and Section 5 presents the estimation results. The final section concludes.

2. INCOME SHOCKS AND ARMED CONFLICT

The relationship between low or negative economic growth and the outbreak of armed conflict is considered one of the strongest, consistent, and most robust associations in the extant literature on civil war (c.f., Collier & Hoeffler, 2004; Hegre & Sambanis, 2006). In spite of this, the channel through which falling income affect the risk of civil war remains little understood.

To begin with, the relationship is theoretically ambiguous. A negative association between falling income and conflict is supported by one of the most influential economic theories holding that individual incentives to rebel rise when economic opportunities and income fall (Collier & Hoeffler, 2004; Grossman, 1991; Hirshleifer, 1995). The focus on individual-level incentive structure also accords with motivation-based accounts for rebel participation. One example is found in the early literature on agrarian revolutions, which explain collective violence as a response to increasing poverty and subsistence crises among the rural working class with the commercialization of agriculture and changing economic relations between landlords and peasant tenants (c.f., Moore, 1966; Paige, 1975; Popkin, 1979; Scott, 1976; Wolf, 1969). Other scholars, however, point out that lower economic output also reduces the spoils to fight over and *ceteris paribus* should reduce the time and resources devoted to fighting (Besley & Persson, 2008; Fearon, 2007). If anything, *rising* revenue will increase the risk of conflict by raising the economic pay-offs from violent predation and heightening the prize of state capture among the elites (Arezki & Brueckner, 2014). A third section of this literature does not dispute the direction of the relationship per se, but interprets it, not as an effect of increased supply of rebel labor with a growing pool of unemployed youth, but as a state capacity effect. Low or negative growth constrains states' investment in military and infrastructure, and thus weakens state counter-insurgency capacity (Fearon & Laitin, 2003; Herbst, 2004).

This theoretical ambiguity is reinforced by inconclusive empirical evidence in support of any of the above contentions. Conflict-growth regressions relying on cross-national research designs make the identification of causal mechanisms futile. At this level of aggregation alternative causal mechanisms, such as lowered opportunity costs or weakened state capacity, are often observationally equivalent. Recent studies have also pointed to the potential bias arising from omitted variables and reverse causality in conventional approaches. Efforts to identify exogenous variation in income shocks have used rainfall variation (Bohlken & Sergenti, 2010; Jia, 2012; Miguel *et al.*, 2004; von Uexkull, 2014) or commodity price shocks (Bazzi & Blattman, 2014; Besley & Persson, 2008; Brückner & Ciccone, 2010). Yet, the results emerging from these studies are inconsistent. Whereas some studies find evidence that negative economic shocks increase the risk of conflict (Brückner & Ciccone, 2010; Miguel *et al.*, 2004; Savun & Cook, 2010), other studies report the opposite (Besley & Persson, 2008), or no effect of price fluctuations on conflict outbreak (Bazzi & Blattman, 2014).

One reason for the inconclusive findings may be that effects are heterogeneous across economic sectors and areas of society—a heterogeneity that is not easily captured in country-level studies. In their sub-national study of violence across Columbian municipalities, Dube and Vargas (2013) exploit the fact that price shocks in the labor-intensive agricultural sector disproportionally affect household income and thus influence the opportunity-cost motive, whereas price shocks in the capital-intensive oil sector disproportionally affect state revenue, and thus influence the pay-offs from state capture (See also Dal Bó & Dal Bó, 2011; Bazzi & Blattman, 2014). Dube and Vargas' micro-level approach allows for the identification of diverging effects and for taking location-specific contextual and spatial factors into account. Yet, the single case study has limitations in terms of external validity. There is hence a need for large-N, comparative work on the effects of economic shocks that moves beyond country-level aggregates, while covering a larger set of countries.

Answering to this gap, this article adopts a meso-level approach by using sub-national data on the characteristics of local agricultural production together with high-resolution spatial data on the occurrence of civil war violence. Utilizing fluctuations in world market prices as an, arguably, exogenous source of variation in the value of local agricultural produce, it studies the effect of location-specific income shocks on the risk of political violence across African countries in the 1990–2010 period.[2] The next section discusses the mechanism linking downturns in the agricultural sector to a higher risk of conflict violence.

3. AGRICULTURAL PRICE SHOCKS AND VIOLENT MOBILIZATION

The opportunity-cost mechanism suggests that lower prices and thus lower returns in the agricultural sector increase the risk of conflict as peasants and wage laborers in the rural economy will see the relative returns from fighting, compared to farming, increase (Collier & Hoeffler, 2004; Grossman, 1991; Hirshleifer, 1995). More specifically, I expect negative agricultural price changes to facilitate the growth of rebel organizations through the effect on rural poverty. The agricultural sector is labor intensive and employs a large share of the labor force in the developing world. Since agriculture accounts for a large share of income for many rural households, external shocks that affect the economic returns from agriculture are likely to significantly affect poverty levels (c.f., Bussolo, Godart, Lay, & Thiele, 2006; De Hoyos & Medvedev, 2011). Agricultural price slumps reduce the economic returns to small-holding farmers, which could jeopardize an often small margin of security against subsistence crisis. They also reduce the demand for unskilled labor and, in turn, wages, for the many rural, often irregular wage earners in the agricultural sector (Polaski, Ganesh-Kumar, McDonald, Panda, & Robinson, 2008). Even subsistence farmers, who need to enter the market to purchase goods for which they are not self-sufficient (e.g., clothes, tools or sugar), will see off-farm income opportunities decline.

Lower income and fewer economic opportunities in the rural economy is likely to facilitate recruitment to armed movements. For unemployed farmers and workers, enlisting as a rebel may provide temporary employment (Humphreys & Weinstein, 2008); be a way to secure access to a livelihood (Walter, 2004); food (Kalyvas, 2006); or give scarce land for farming (Wood, 2003). Engaging in or supporting collective violence may also be a response to increased economic competition. Tolnay and Beck (1995), for example, show how an increase in lethal mob violence against southern blacks in the US in the late 19th and early 20th century mirrored the decreasing value of cotton crops. They attribute this relationship to economic competition between marginal black and white laborers, as lynching was used to facilitate labor substitution from black to unskilled white laborers in periods of economic decline.

Agricultural price shocks could induce grievances and influence the opportunity cost of rebellion, not only through lower wages and fewer opportunities in the agricultural labor market, but also by limiting the ability of the government to placate the peasantry. State economic policies, aid, and service delivery are often used to inoculate civilians against the appeals of insurgent and to generate support for the government (Beath, Christia, & Enikolopov, 2012; Berman, Shapiro, & Felter, 2011). Yet, tax revenue from agriculture constitutes a major source of state income in developing countries. When prices drop, fewer funds are available for subsidies to agricultural products and state spending on public goods and social services. The government is thus restrained in the efforts to cushion the negative effects of local economic shock, making it more difficult for the state to dissuade peasants from supporting a rebellion.

The grievance aspect is important because civilian support is vital for sustaining a viable insurgency (Kalyvas, 2006). The case literature is ripe with examples of rebel movements actively seeking to placate the peasantry. Le Billon (2005), for example, describes how the FARC guerilla units in Colombia during the conflict provided protection on peasant land holdings and guaranteed a minimum price for both cocoa and agricultural products because peasant productiveness was seen as key to the viability of insurgency. Poverty not only creates frustrations that may solidify rural support for rebel's radical agendas, it also creates a vulnerability that allows ties of reciprocity between civilians and armed groups to form (Justino, 2009). During a conflict, rebel groups often control access to infrastructure, land, and economic markets and also enforce restrictions on people's ability to move to adapt to changing economic circumstances. Poorer households face higher costs of non-participation in violent mobilization than those with larger economic margins, due to the costs of staying neutral when access to land and markets are controlled by warring actors (Justino, 2009). Local income shocks may thus precipitate recruitment and breed support for armed groups.

The argument linking downturns in the rural economy to an increased risk of armed conflict resonates with a number of studies pointing to the salient rural dimension of many rebellions (Desai & Eckstein, 1990; Mason, 2004; Kalyvas, 2007). Numerous case studies suggest that rural dwellers often constitute a main pool of recruitment and civilian support for insurgencies, and that many of the issues that motivate these insurgencies originate in the rural economy.[3] Indeed, survey evidence, for example from the war in Sierra Leone (Humphreys & Weinstein, 2008) and Rwanda (Verwimp, 2005) shows that farming represents a large proportion of the rebel recruits' pre-war occupation. The impact of negative agricultural price changes on rural poverty and, in turn, the opportunity-cost motivation suggests one important mechanism for explaining violent mobilization in the rural context.

The above argument does, however, come with some caveats. To begin with, there is an ongoing debate about the poverty effect of changing agricultural prices (Aksoy & Isik-Dikmelik, 2010). Since food prices may co-vary with agricultural commodity prices, price shocks could also heighten the price of the food basket.[4] Whether it is the consumption channel or income channel that dominates when determining household welfare will depend on the profile of the household as net consumers or producers of food (Aksoy & Isik-Dikmelik, 2010). Much of the literature linking rising food prices to political instability has focused on the plight of urban consumers, whose income has fewer links to agricultural markets and are primarily negatively affected by rising agricultural prices. Rural households, on the other hand, are often producers of food and thus affected by price changes also through the income channel (De Hoyos & Medvedev, 2011). In theory, rising prices should thus benefit farmers and increase their income. The pass-through effect of higher prices to producers is, however, also modified by the workings of the commodity market. State-controlled marketing boards or other middlemen have been known to keep prices to cultivators artificially low to placate urban consumers and reap profits (Bates, 1981). Increasing deregulation of the commodity market has also implied that marketing intermediaries, engaged in commodity speculation, capture much of the benefits when prices soar. Cultivators of food may thus not be able to fully benefit from price booms, as input prices also rise and output prices are so volatile that the benefit does not accrue to producers (Ghosh, 2010).

The overall argument nevertheless suggests that low or falling value of local agricultural production will increase the incentives of rural dwellers to join or support a rebellion. I hence derive the following hypotheses:

Hypothesis. A negative change to the value of local agricultural production will increase the likelihood of armed conflict events.

4. DATA AND RESEARCH DESIGN

The data used to evaluate the hypothesis cover Africa from 1990 to 2010. Africa arguably represents an appropriate sample of countries to examine the relationship between changes in the value of local agricultural products and the risk of armed conflict. First, the continent is dependent on the agricultural sector for income and employment, particularly the rural poor. An estimated 60% of the workforce is employed in agriculture, and more than 80% of the region's poorest households depend directly or indirectly on farming for their livelihoods (World Bank, 2007). This condition is central for drawing inference regarding the suggested opportunity-cost mechanism. Second, the continent has seen a number of armed conflicts, while also displaying large temporal and spatial variation in their occurrence.

To evaluate the opportunity-cost mechanism the level of measurement is important. The level of resolution at which this mechanism operates dictates a move away from conventional country-year research designs, toward a more disaggregated approach. Existing micro-level studies have been able to match data on employment and wages in the rural sector with information about participation and intensity of violence, while also accounting for location-specific characteristics (c.f., Humphreys & Weinstein, 2008; Dube & Vargas, 2013; Verwimp, 2005; Friedman, 2013; Nillesen & Verwimp, 2010). By focusing on specific countries, these studies are able to directly evaluate arguments linking income shocks to individual's participation in conflict. Yet case-specific studies have limitations in terms of generalizability. Making a compromise between macro-level, cross-country studies and micro-level approaches that have focused on single conflicts, this study adopts a meso-level approach: it focuses on spatial and temporal variation across sub-national units in a large number of countries over a 20 year period. While enforcing limitations in terms of the quality of available data and the ability to incorporate context-specific factors, this disaggregated research design allows me to account for unit heterogeneity in a large-N study.

My sub-national units of analysis are defined by a spatial–temporal grid structure covering Africa in the years 1990 to 2010. The grid has a spatial resolution of 0.5 decimal degrees latitude/longitude (approximately 55 × 55 km at the equator), dividing the territory into equally sized cells. The annual observation of each cell, i.e., the cell-year, is the unit of analysis. The grid is taken from the standardized PRIO-GRID (Tollefsen, Strand, & Buhaug, 2012). Relying on the PRIO-GRID standard implies streamlining the choice of areal unit, which helps to counteract arbitrariness in the growing literature utilizing spatial data, and to facilitate replication and extension of existing work.

My dependent variable is a binary indicator of armed conflict events within the grid cell that year. The data are taken from the Uppsala Conflict Data Program Geo-Referenced Event Dataset v.1.0 (UCDP GED) (Sundberg & Melander, 2013). An armed conflict is defined by the UCDP GED as 'a contested incompatibility between a government and one or more opposition groups that results in at least 25 battle deaths in a year' (Gleditsch, Wallensteen, Eriksson, Sollenberg, & Strand, 2002). For the cases meeting these criteria, UCDP GED records all instances of fatal violence (i.e., events with at least one fatality) in an events-based format, where each event is recorded with a geographic location and a date. The data collection is based on news sources, NGO reports, books, case studies, historical archives, databases, and country-experts. Through spatial overlay operations, I assign the conflict events to the spatial grid structure and construct a dummy variable for whether an event occurred in that cell that year or not. My dependent variable captures the incidence of violence and not only outbreak, since the argument pertains to the rebel group's participation constraints and to the civilian support for rebellion throughout the conflict. In total, 3,140 cell year observations are recorded with armed conflict violence during the period.

My independent variable is the changing value of local agricultural production, proxied by a local agricultural price change index. To identify exogenous variation in agricultural revenue at the local level I combine spatial, time-invariant data on the distribution and output of various agricultural crops with time-varying data on international prices on these crops. The spatial data on crop production patterns come from the Spatial Production Allocation Model (SPAM) (You *et al.*, 2011; You, Wood, & Wood-Sichra, 2006). As input, SPAM uses the Agro-Maps from the Food and Agriculture Organization of United Nations (FAO), alongside numerous other sources that provide agricultural statistics at the sub-national level, including the World Food Program, agricultural performance surveys, national bureaus of statistics, and regional NGOs. SPAM provides grid maps with a 5-min resolution (meaning approximately 10 × 10 km at the equator) of crop production patterns and output for a range of major crops across the world. One drawback of these data is that the maps are not time varying and the production data contained in them are only from the year 2000. Crop selection and output is to some extent influenced by geographic and climatic conditions, traditions and expertise, which change only slowly. Time-invariant data might hence capture overall patterns of agricultural production. However, cultivation patterns do also change, both in response to fluctuations in the demand for particular commodities, to altered physical conditions (climatic changes or soil depletion), or even man-made disasters such as war-induced refugee flows. These changes are not reflected well in these data. The lack of better-quality, time-varying data with high spatial resolution is a limitation of this analysis. To be able to construct a measure of the value of the cultivated commodities, I focus on those crops where price statistics from the International Monetary Fund are available (as described below). Through spatial overlay operations between the individual crop-production maps and the spatial grid, I construct measures that map the local production areas and output for each crop within my units of analysis.

Local commodity prices and local rebellion could partly be co-determined, making local prices endogenous to local violence. I therefore rely on international commodity prices to identify exogenous variation in the value of the local agricultural production. The price statistics are from the International Monetary Fund (2013) and cover the following crops in the SPAM data: coffee, cotton, groundnuts, maize, rice, soybeans, and wheat. Jointly, these represent a bundle of important export commodities for African countries. Following Brückner and Ciccone (2010), I begin by aggregating the monthly international commodity price data to an annual price series for each commodity (with the 1990 value of all commodities set to 1). I then construct my main explanatory variables of interest by calculating a local agricultural price index for cell c in time t as

$$AgriPrice_{ct} = \sum_{i=1}^{n} \omega_{ci} P_{it}$$

where ω_{ci} is the time-invariant share of agricultural i production in cell c and P_{it} is the annual price series for each agricultural produce i. The annual growth rate of this location-specific agricultural price index, which ranges from -0.39 to 1.15, is my main explanatory variable. I enter the index at $t-1$, to ensure the right temporal ordering.

Many studies substantiate the identification assumption: that international agricultural price fluctuations are reflected in the domestic economy (Bazzi & Blattman, 2014; Deaton, 1999). Polaski *et al.* (2008), for example, estimates a strong negative effect of lower prices on wheat and rice on the demand for unskilled labor, income levels and wages in the rural sector in India. Yet, there are two potential sources of bias related to this measure. First, as discussed in the theory section, changes in international prices may not be fully transmitted to farmers. If the degree of a pass-through varies systematically by factors that are also related to conflict (such as the openness of the domestic market or distance to capital), it could bias the results. [5] Hence, to control for unobserved, time-invariant characteristics that may influence the risk of conflict, I include panel-fixed effects in the main specifications. I also include year dummies to control for time trends in the risk of conflict that may not be accounted for by my independent variable, for example relating to the changes in global economic markets and trade liberalization. The assumption that international prices will be reflected in the income of local farmers is nevertheless a limitation of this study.

Another potential source of bias is endogeneity. We could be concerned that export prices for the seven commodities considered here are not exogenous to domestic instability and political unrest in the crop-producing countries in the analysis. I have consulted data from various sources, and in all but one case (Côte d'Ivoire with respect to coffee) individual countries' exports of these commodities constitute less than 5% of world market. Hence, their global export shares are arguably too small to permit individual countries to have much effect on world market prices (Deaton, 1999). [6] Overall, endogeneity should also be less of a concern studying local patterns of violence, as international prices are less likely to respond to conflict dynamics within sub-national units than to country-level outbreaks of armed conflict. The independent variable is hence arguably both exogenous and location specific.

As noted, I include cell fixed effects and year dummies to control for unobserved heterogenity among the units in the main models. For robustness, I also control for a set of potentially confounding variables. First, I control for local income. Many studies suggest that poor areas have a higher risk of violence (c.f., Collier & Hoeffler, 2004; Miguel *et al.*, 2004), although studies suggest that the relatively richer areas within poor countries see a higher risk of violent conflict (Buhaug, Skrede Gleditsch, Holtermann, Østby, & Forø Tollefsen, 2011). Sub-national patterns of poverty may also correlate with patterns of agricultural production. The spatially disaggregated data on per capita gross cell product (the cell-equivalent of GDP) comes from the G-ECON project (Nordhaus, 2006). Second, I control for population size in the cell. Violent conflict is found to be more likely in more populous areas (Hegre & Raleigh, 2009), and population patterns and economic geography are dependent. The data are taken from Center for International Earth Science Information Network (2005) and are reported in five-years intervals. Both variables are log-transformed to reduce the influence of extreme values, and entered at $t-1$. [7] Ethno-political grievances have been linked to a higher risk of violence conflict (c.f., Cederman, Wimmer, & Min, 2010). Since marginalized groups are more likely to reside in the state periphery, ethnic geography might be correlated with patterns of economic activity. I therefore include a binary variable denoting whether an ethnic group that is excluded from political power resides in the grid cell (Cederman *et al.*, 2010; Wucherpfennig, Weidmann, Girardin, Wimmer, & Cederman, 2011). Existing studies testify to spatial and temporal correlation in conflict processes, giving rise to what (Collier *et al.*, 2003) calls local 'conflict traps'. To account for temporal dependence in the dependent variable I include a variable counting the number of years since last occurrence of violence in the grid cell, together with its squared and cubed term (Carter & Signorino, 2010). To account for spatial correlation in the dependent variable. I include a spatial lag, i.e., the value of the dependent variable within the unit's second order neighboring cells at $t-1$, as a covariate in my models. [8]

5. EMPIRICAL ANALYSIS

I evaluate the effect of agricultural price changes on the risk of civil war violence in a series of time-series cross-sectional models. In my main models I include cell-fixed effects, which capture time-invariant, cell-specific characteristics that may influence the risk of armed conflict (such as distance to capital, roughness of the terrain, or other geographical factors), as well as year dummies, which capture time trends in the causes of armed conflict that are not well accounted for by my independent variable.

I use several different estimation approaches, each with certain advantages and disadvantages. The main results are reported in Table 1. Model 1 reports the results using a linear estimator with cell fixed effects and robust standard errors after clustering at the level of the cell. However, since my dependent variable is a binary indicator of whether conflict violence occurred in the cell during that year or not, a conditional logit estimator (that also accounts for cell-specific characteristics) may better reflect the underlying data-generating process than the linear probability model. Results from a conditional logit is thus reported in Model 2. In a conditional logit, however, all panels that do not experience conflict are dropped from the model and the panels that never experience violence have no impact on the parameter estimates. Moreover, it is very difficult to provide an interpretation of substantive effects based on a conditional logit model. [9] In Model 3 I therefore estimate a logit model, with robust standard errors clustered on the cell. In the place of cell-fixed effects and year dummies, I control for a number of potentially confounding variables, including population, gross cell product, the presence of politically marginalized ethno-political groups, as well as controls for temporal and spatial dependence. Model 4 reports the results from the same model, but using a rare-event logit estimator, since logit estimation may introduce bias when the outcome of interest is a rare event (Tomz, King, & Zeng, 2003). Finally, as a robustness, Model 5 report the results using linear estimator and the full range of cell-fixed effects, year dummies, time-varying control variables and controls for spatial and temporal dependence.

The results are consistent across all models: higher values on the local agricultural price index are associated with a lower risk of conflict violence in the cell and the coefficient estimate is statistically significant at the 5% level or higher. Jointly, the estimated models account for a range of potentially confounding variables, including spatial and temporal dependence, and unobserved heterogeneity across units and over time. The evidence thus lends strong support to the argument that increasing value of local agricultural output reduces the risk of violence in the cell. Positive changes to the local agricultural price index—associated with increased employment opportunities and higher returns—are associated with a lower risk of violence at the location.

In model 6, I test whether the impact of negative price shocks is different from the impact of positive price shocks by including in the regression an interaction term between the agricultural price change variable and an indicator that is 1 if and only if the agricultural price index is negative. The linear effect of the agricultural price change variable, which now refers to the conditional effect of positive changes, remains negative and statistically significant. The interaction

Table 1. *Agricultural price index and armed conflict*

	(1) (FE LPM)	(2) (FE Logit)	(3) (Logit)	(4) (ReLogit)	(5) (FE LPM)	(6) (FE LPM)
Agri. price change$_{t-1}$	-0.010^{***}	-0.668^{***}	-0.660^{***}	-0.660^{***}	-0.010^{***}	-0.014^{***}
	(0.004)	(0.247)	(0.166)	(0.166)	(0.004)	(0.004)
GCP pc$_{log,t-1}$			0.180^{***}	0.180^{***}	-0.001	
			(0.027)	(0.027)	(0.002)	
Population$_{log,t-1}$			0.299^{***}	0.299^{***}	0.003	
			(0.023)	(0.023)	(0.004)	
Excluded ethnic group$_{t-1}$			0.273^{***}	0.273^{***}	0.004^{**}	
			(0.056)	(0.056)	(0.002)	
Time since conflict			-0.820^{***}	-0.819^{***}	-0.051^{***}	
			(0.033)	(0.033)	(0.003)	
Time since conflict sq			-0.002^{***}	-0.002^{***}	-0.000^{***}	
			(0.004)	(0.004)	(0.000)	
Time since conflict cu			-0.002^{***}	-0.002^{***}	-0.000^{***}	
			(0.000)	(0.000)	(0.000)	
Spatial lag, conflict$_{t-1}$			2.146^{***}	2.146^{***}	0.036^{***}	
			(0.070)	(0.070)	(0.002)	
Agri. price change $*$ Negative						0.040^{***}
						(0.011)
Negative						0.004^{***}
						(0.001)
Constant	0.027^{***}	–	-7.264^{***}	-7.262^{***}	0.076	0.027^{***}
	(0.002)	–	(0.386)	(0.386)	(0.049)	(0.002)
Cell fixed effects	Yes	Yes	No	No	Yes	Yes
Year fixed effects	Yes	Yes	No	No	Yes	Yes
Observations	147,861	21,483	142,156	142,156	142,156	147,861
Number of groups	7,041	1,023	7,036	67,036	7,036	7,041

Robust standard errors clustered on the grid cell in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

term is positive and significant, suggesting that the effect of negative change to the local agricultural price index is particularly detrimental for the risk of violence occurring in the cell. An increase in the local agricultural price index by 30%, is associated with a reduction in the annual predicted probability of violence in the cell of about 0.4% in absolute terms. [10] A 30% decrease in the local agricultural price index increases the annual predicted probability of violence in the cell with 4.4% in absolute terms. [11] If the substantive effects seems negligible in absolute terms, remember that civil war violence is a low-probability event. Only 2.1% (or 3,140 of the 147,861) grid cells in the analysis ever experience such violence. In this context, the reported substantive effects are non-negligible. The results from Model 6 suggest that the effect of negative income shocks are not directly offset by subsequent equivalent positive changes.

Table 2. *Robustness tests, agricultural price index and armed conflict*

	Multiple lags (1)	Alternative IV (2)	DV precision (3)	DV count (4)	Only 00/01 (5)
Agri. price change$_{t-1}$	-0.016^{***}		-0.009^{***}	-0.572^{***}	-0.058^{***}
	(0.004)		(0.003)	(0.202)	(0.020)
Agri. price change$_{t-2}$	-0.014^{***}				
	(0.004)				
Agri. price change$_{t-3}$	-0.014^{***}				
	(0.005)				
Agri. value change$_{log,t-1}$		-0.010^{***}			
		(0.004)			
Constant	0.015^{***}	0.150^{***}	0.021^{***}	-1.108^{***}	0.025^{***}
	(0.001)	(0.052)	(0.002)	(0.080)	(0.002)
Cell fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	133,779	135,760	147,861	21,483	14,082
Number of groups	7,041	6,788	7,041	1,023	7,041

Robust standard errors clustered on the grid cell in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Method of estimation is least squares in Models 1–3 and 5, and conditional negative binomial regression in Model 4.

I proceed to further explore the robustness of the relationship. These models are reported in Table 2. Due to the concern of omitted variable bias in pooled data and efficiency loss using fixed effects with binary dependent variable models, I estimate a linear probability model with cell-fixed effects and year dummies as my main specification. None of the robustness tests reported in Table 2 are, however, sensitive to using a fixed effect logit (i.e., conditional logit) instead.

First, there is often a time-dependence in price shocks, and it might take several periods for price changes to impact income and employment patterns. This leads to a correlation between the current price change and the error term. In Table 2, Model 1, I therefore introduce negative price change with two additional lags. The agricultural prices change at $t-1$, $t-2$ and $t-3$ are all negative and significant, the two latter slightly smaller in magnitude. This suggests that the conflict-inducing effect of negative price changes are seen also in years following a drop in prices and that the total effect of a negative price shock is larger than suggested above. A 20% drop in the local agricultural price index is associated with a 0.3% increase in the predicted annual risk of violence in the cell, and an additional 0.6% with a lag. Summing the effect on impact and the lagged effect yields a total increase in the risk of violence of 0.9%. Second, as a robustness I construct an alternative measure of changes to the value of local agricultural production, which more directly reflect changes to the value of local agricultural produce. The variable is computed by summing up the value of the produced commodities (quantity $*$ international price) for each cell-year. I take the log of the value of local agricultural produce to reduce the impact of the most extreme values, and enter it at $t-1$ to ensure the right temporal order. The main result remains the same. Third, a potential problem with the data for the dependent variable is measurement errors in the geographical location of an event. The UCDP GED dataset provides precision codes from 1 to 7, which convey the level of certainty surrounding the geographical location. In Table 2, Model 3, I report a model where I only retain those events where the geographical location is considered to be more exact. [12] The agricultural price change index remains negative and statistically significant. Fourth, I utilize an alternative indicator of conflict violence, using the count of the total number of conflict events recorded by UCDP-GED within the grid cell that year as my dependent variable (Sundberg & Melander, 2013). The results from estimating a conditional fixed effects negative binomial regression model are reported in Model 4. These are in line with the previous findings. [13] Fifth, production data are only available from the year 2000. Relaxing the assumption that these data are generally representative of the agricultural output across the whole period, Table 2, Model 2 reports the results using only the years 2000–01. The main result remains the same.

In addition to these robustness tests, I have also ensured that the relationship between the agricultural price change index and civil war violence is robust to controlling for rainfall shortages. I have tried to include a variable denoting whether the location experienced drought, i.e., significant negative deviations from normal rainfall patterns. [14] The drought variable is positive, but not significant. The main result pertaining to agricultural price shocks remains unaltered. I have also ensured that the results are robust to controlling for whether oil or diamonds are extracted within the grid cell. [15] The estimates for petroleum fields and diamond mines are both positive, but not significant. [16]

For the control variables, the results are largely in line with the existing literature. The variables accounting for spatial and temporal dependence are all significant. This spatial and temporal correlation in conflict processes suggests repeating cycles of violence in conflict-affected locations—or what Collier *et al.* (2003) refer to as a 'conflict trap'. Indeed, violent conflict often spill over into neighboring areas through for example refugee flows, spread of small arms or other diffusion effects and thus create legacies that increase the risk of renewed fighting (Gleditsch & Weidmann, 2012; Buhaug *et al.*, 2011). The result for the local GDP per capita measure is inconsistent across the models, but mostly positive and significant. This result does not change if the agricultural price index is excluded from the model. The results are consistent with the findings of Buhaug *et al.* (2011), that in poor countries, areas with higher income attract violence through a"honey pot effect". Population is a positive and significant predictor of armed conflict across most models, which may suggest that more populous areas face lower barriers for recruitment into armed groups. Finally, the presence of excluded ethno-political groups is associated with an increased risk of political violence. This finding is in line with previous studies, suggesting a strong relationship between political marginalization of ethnic groups and a higher risk of armed rebellion (Cederman *et al.*, 2010; Wucherpfennig, Metternich, Cederman, & Gleditsch, 2012). Discriminatory policies may benefit rebel organizations, since members of politically excluded ethnic groups may harbor grievances that increase collective group solidarity and galvanizes the determination of individual fighters (Wucherpfennig *et al.*, 2012).

6. CONCLUSION

During the past decade, the issue of armed conflict has been high on the agenda of the major development organizations. There is consensus that armed conflict is a development issue, with low economic development and armed conflict reinforcing each other. Yet, cross-national growth-conflict regressions offer limited insights on what factors and dynamics heighten vulnerability among the poor and what policy choices might alleviate conflict risk. This article addresses this important question by identifying one of the channels through which negative income changes influence the risk of armed conflict. It shows that negative changes to the value of local agricultural production increases the risk of armed conflict in Africa. This relationship is robust across a number of estimation strategies and model specifications, and is a residual effect controlling for time-invariant unobserved heterogeneity among the units, time trends, and a broad range of confounding variables. These results are in line with recent studies by for example Dube and Vargas (2013) and Berman and Couttenier (2013), who also finds that income shocks to the labor-intensive agricultural sector increase the risk of armed conflict.

There are at least two explanations linking negative economic growth and an increased risk of conflict: one holding that conflict risk increases individual incentives to rebel as opportunity costs go down; a second holding that conflict risk increases by weakening the state's coercive capacity. The effect of the particular income shocks studied in this study is most consistent with the first of these accounts. While falling prices on agricultural products is also affecting government income in Africa, the identified relationship manifests itself at the local level in those agricultural areas that are directly affected by economic hardship. These findings thus lend more support to the opportunity-cost mechanism than to the weak-state argument, as the latter would imply that the influence of negative income changes primarily are transmitted from the state capital. This does not exclude the possibility, however, that state policies might feed into the plight of rural populations, as the state's ability to cushion the negative effects of price slumps through subsidies and local co-optation strategies is also reduced.

How do these results align with recent research suggesting that increases in the price of food precipitate riots and societal unrest by heightening the price of the food basked (c.f., Bellemare, 2014; Bush, 2010; Hendrix & Haggard, 2015; Smith, 2014)? The commodities examined in this analysis are not primarily staple food produced for consumption at domestic markets. The findings might therefore not be incompatible. Higher food prices might act as a trigger for urban protest and less organized forms of societal unrest among urban dwellers, but it might not be sufficient to induce participation in more organized and violent forms of collective action. Among the rural population in the countryside where most of the agricultural output is produced, the income channel will often be more important in determining the influence of changing prices on agricultural products. Because an economy based on farming is more likely to favor armed resistance than one based on wage labor (c.f., Kalyvas, 2007), economic grievances related to falling prices and loss of livelihood is perhaps more likely to trigger organized and violent forms of collective action among small-holding farmers and rural laborers. Changing prices of agricultural products might thus have heterogeneous effect within societies, depending on economic and societal structures.

NOTES

1. For a critique of the methodological individualism of economic models of conflict, see Cramer (2002).

2. For a recent study adopting a similar approach and reaching similar conclusions, see (Berman & Couttenier, 2013)

3. See for example Chauveau and Richards (2008) on Cote d'Ivoire; Mason (2004) on Peru; Wood (2003) on El Salvador; Le Billon (2005) on the Philippines; and Richards (2005) on Sierra Leone and Liberia.

4. Higher food prices and rising food insecurity have, in turn, been linked to an increased risk of riots and urban unrest (Bellemare, 2014; Bush, 2010; Hendrix & Haggard, 2015; Smith, 2014).

5. In many developing countries, the pass-through effects of international prices is for example modified by government agricultural policies. In the 1960s and 1970s, many African governments put in place policy measures that distorted the local price of agricultural produce. Trade barriers, taxes, subsidies, and government interventions predominantly favored the urban sector at the expense of farming households, as a way to co-opt important segments of the population into supporting the regime. Government intervention in price systems may also be a mechanism to reduce volatility. During the past two decades, prize distortions have been significantly reduced as African governments have undertaken extensive reforms to improve price incentives for farmers and reduce government intervention (Anderson, 2009). Hence, international prices of agricultural products are arguably a far better measure of the value of local agricultural produce today than it would a few decades ago.

6. Data are taken from the International Coffee Organization (http://www.ico.org); the United States Department of Agriculture's Economic Research Service (http://www.ers.usda.gov/data-products) and the International Trade Center (http://www.tradeforum.org). I have also rerun all analysis without Côte d'Ivoire as a robustness. This does not affect the main results.

7. Both variables are taken from the PRIO-GRID, and the codebook provides more information on how the data are allocated to the spatial grid structure (Tollefsen *et al.*, 2012)

8. Since the introduction of lagged dependent variables (or transformations thereof) in a fixed effect regression may introduce bias (Nickell, 1981), temporal and spatial controls are added as robustness to the main model.

9. The conditional logit model does not include an intercept nor does it estimate the fixed effects, making it difficult to calculate substantially interesting quantities.

10. This number is the estimate for the agricultural price index in Table 1, Model 6 multiplied by 0.30.

11. This number is the estimate for the agricultural price index in Table 1, Model 6 multiplied by −0.30 plus the estimate for the interaction term.

12. I use all events that are coded with 1–3 on the geographic location precision variable.

13. When using an ordinary least square estimator instead, the result is not significant.

14. The variable is operationalized using the annualized SPI6 index based on monthly precipitation data provided by the Global Precipitation Climatology Centre (Rudolf, Becker, Schneider, Meyer-Christoffer, and Ziese, 2010). The measure is taken from the PRIO-GRID dataset (Tollefsen *et al.*, 2012).

15. The two dummy variables are constructed through spatial overlay operations with geographical data on petroleum extraction (Lujala, Rød, & Thieme, 2007) and on diamond extraction (Gilmore, Lujala, Gleditsch, & Rød, 2005)

16. The robustness tests not shown in tables are available upon request.

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