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Food security and conflict

Empirical challenges and future opportunities for research and policy making on food security and conflict

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Charles Martin-Shields and Wolfgang Stojetz

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Contents

Tables

Figures

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Empirical challenges and future opportunities for research and policy making on food security and conflict

Charles Martin-Shields[1] and Wolfgang Stojetz[1]

[1] International Security and Development Center

Abstract

During the previous decade there has been an increased focus on the role of food security in conflict processes, both in the academic and policy communities. While the policy community has pushed forward with new programs, the academic debate about the causal linkages between food security and conflict remains debated. This article emphasizes the endogeneity that characterizes the coupling between food (in)security and violent conflict. We make three contributions. First, we define conflict and food security using the standard Uppsala Conflict Data Program and the FAO databases, and illustrate how intervening factors influence the relationship between conflict and food security at the micro and macro levels. Second, we provide a comprehensive review of the literature on linkages between food security and conflict, focusing on findings that account for endogeneity issues and have a causal interpretation. Third, we highlight policy-affecting data gaps beyond endogeneity and chart ways forward to improve the existing bodies of data and support new data collection to fill the academic gaps and support policy making. Our article supports to the ongoing debate around the causal relationship between food security and conflict, while also providing policy makers with analysis of data challenges and opportunities for innovation in food security and peacebuilding.

Keywords: food security, conflict, endogeneity, data, peacebuilding and development.

JEL codes: Q18, O38, F51, B41

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1 Introduction

Food insecurity affects the lives of millions of people across the world and is increasingly concentrated in conflict-affected regions. All 19 countries the FAO currently classifies as being in a protracted food crisis are also currently affected by conflict and violence (Holleman *et al*., 2017). Globally, 60 percent of the 815 million undernourished individuals and 79 percent of the 155 million stunted children live in countries affected by violent conflict (FAO *et al*., 2017). Our article provides a review of the key concepts and findings across the food security and conflict literature, acting as a reference for future research and policy efforts.

Monitoring food insecurity in conflict-affected countries and understanding the linkages between food insecurity and violent conflict, as well as the positive relationships between food security and stability, is crucial to informing evidence-based interventions from local, national and international practitioners and policymakers. Yet, understanding the relationship between food security and violent conflict faces severe "endogeneity" challenges. Structural factors at both the macro- and micro-levels, e.g. state capacity and household income, are often correlated with both food security and conflict outcomes. These "confounding" factors thus complicate causal analyses of the mechanisms linking conflict and food security.

This article emphasizes the endogeneity that characterizes the coupling between food (in)security and violent conflict. We make three contributions. First, we define conflict and food security using the standard Uppsala Conflict Data Program and the FAO databases, and illustrate how intervening factors influence the relationship between conflict and food security at the micro and macro levels. Second, we provide a comprehensive review of the literature on linkages between food security and conflict, focusing on findings that account for endogeneity issues and have a causal interpretation. Third, we highlight policy-affecting data gaps beyond endogeneity and chart ways forward to improve the existing bodies of data and support new data collection to fill the academic gaps and support policy making.

2 Conflict, food security and endogeneity

This section conceptualizes violent conflict, food security, and the endogeneity issues that one faces when empirically analyzing the two phenomena and their interdependencies.

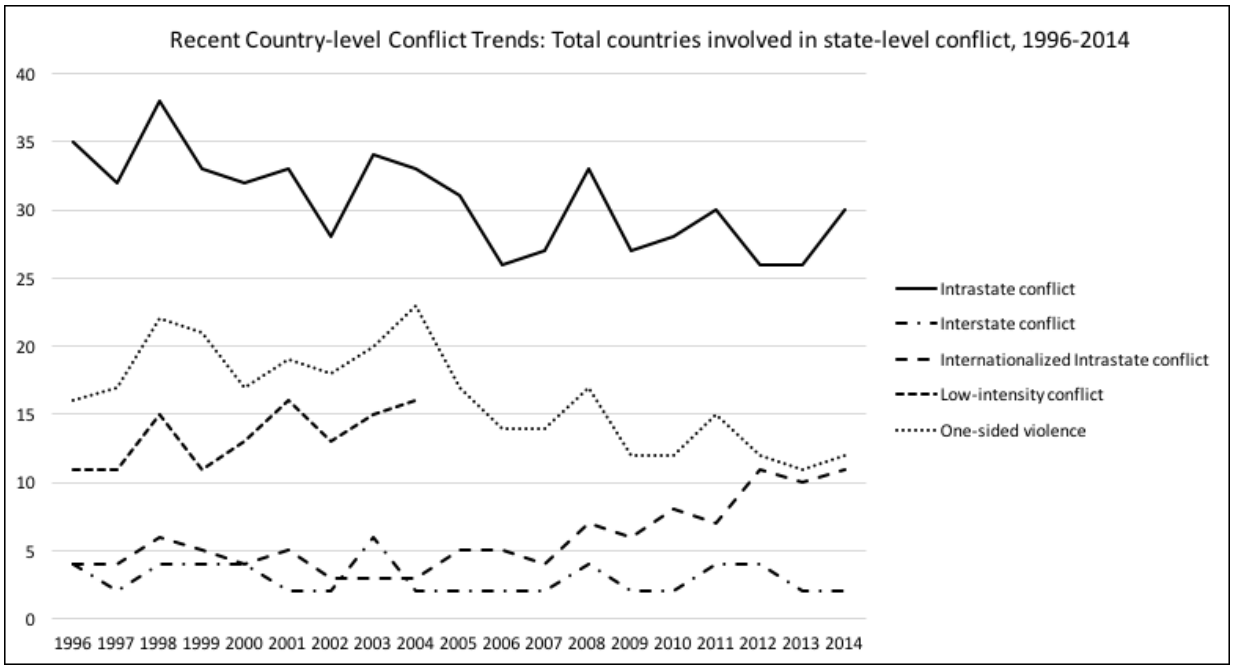
2.1 Conflict

Defining and measuring "conflict" is not straightforward. Across quantitative studies, the event-based measures and categories developed by the Uppsala Conflict Data Program have become a standard approach to conflict at the national level (Croicu and Sundberg, 2017). UCDP has a number of datasets available that code and define different types of conflict, based on the actors involved and geo- and time-coded 'battle deaths'. In general, 1 000 battle deaths in a year is the threshold for a country being at war. Battle deaths are verified fatalities that are a direct result of fighting; on the other hand, violence against civilians is not captured in these data. We focus on five main conflict types quantitatively defined by UCDP and add a special dataset on violence against civilians:

- "Low-intensity conflict" includes periods of conflict where violence or contestation is taking place at more localized levels, and at a lower intensity (fewer than 1,000 battle deaths) than a full-scale civil war (Melander, Möller and Öberg, 2009).
- "Interstate conflict" is traditional country-versus-country conflict (Pettersson and Wallensteen, 2015).
- "Intrastate conflict" is a conflict within a country where one side is the government and the other side is a non-state group (Pettersson and Wallensteen, 2015).
- "Internationalized intrastate conflict" is defined the same way as an intrastate conflict, but includes significant involvement from other countries (Pettersson and Wallensteen, 2015).
- "One-sided violence" is the direct targeting of civilians by government or non-state forces (Eck and Hultman, 2007).

Figure 1 shows recent global trends in these types of conflict. Interstate conflict remains the one that occurs at the highest rate and should thus attract more of our attention. Internationalized intrastate conflicts are also increasing, as countries get involved more in the intrastate conflicts of other countries. One-sided violence has been on the decline, and we lack a long timeline of data on low-intensity conflict.

Figure 1 Timelines of global conflict types, 1996–2014



Source: Data from UCDP (2017) database (Croicu and Sundberg, 2017).

These definitions provide opportunities to ask questions about why and how the phenomena they describe should have an influence on food security. The short time frame was selected for data comparability; the food security data discussed in the next section shares similar timelines, so the utility of looking at conflict data going back to 1946 is less important. For example, an Interstate conflict is likely to have different systemic effects on food security than localized low-intensity conflict. These definitions can be useful in understanding logical directions of causation; for example, without looking at data, the definitions above allow us to ask whether it makes logical sense for something like one-sided violence to have an impact on food access or food price variation? At a more granular level, are battle deaths an appropriate way to understand conflict in relation to a complex issue like food security? To take this framing a step farther the next section explains the FAO's categorical definitions of food security.

2.2 Food security

The FAO categorizes food security into four pillars: food availability, access, stability, and utilization (FAO, 2017). Each pillar captures a different aspect of food security. The pillars can generally be understood thus:

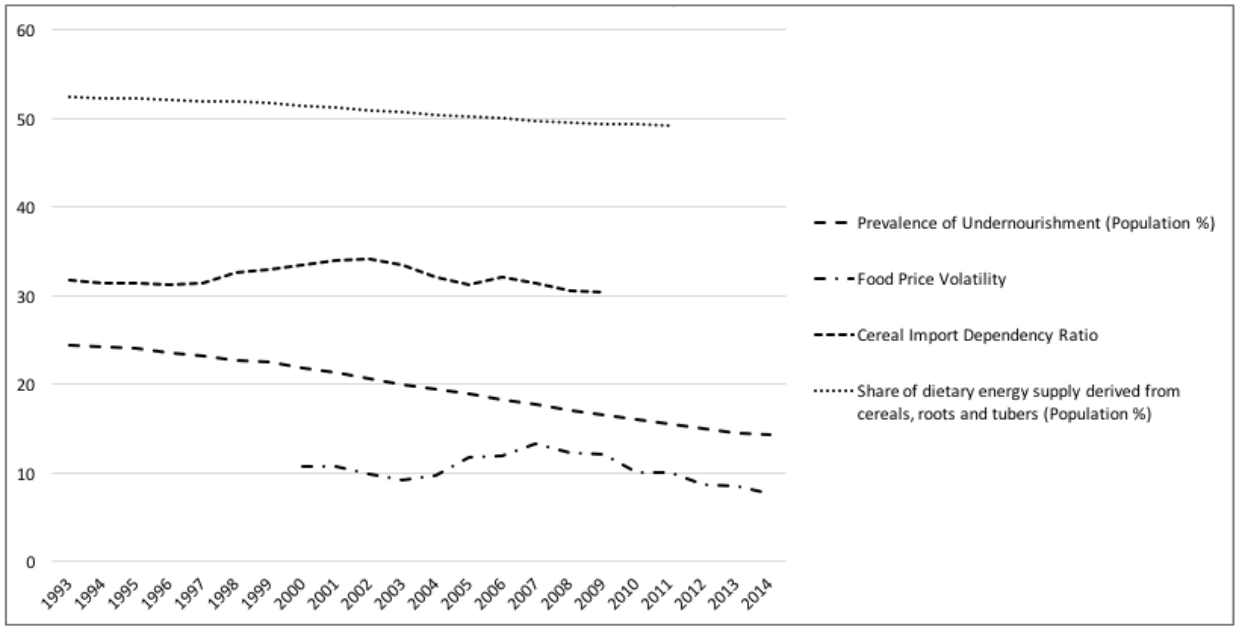
- Availability: This pillar focuses on availability of necessary calories at the individual level, as well as the types of calories available nationally (e.g. cereals versus animal protein).
- Access: This pillar contains variables that measure physical infrastructure for bringing food to market, as well as individual level indicators of whether people have access to the necessary number of calories per day.

- Stability: The variables in this pillar measure dependence on food imports, domestic price variability, and variation in land equipped with irrigation.
- Utilization: This pillar captures data on primarily anthropometric indicators of whether people are able to use available calories; relevant data includes measures on wasting, stunting, and low weight among children.

FAO data on food security is available as a suite on the FAO statistics website (FAO, 2017) and predominantly describes outcomes reported on an annual basis. For our empirical exercise we choose five variables that are analogous to data used in previous research efforts and provide the best coverage across all countries. “Prevalence of Undernourishment”, “Depth of Food Deficit”, and “Share of dietary energy supply from cereals, roots and tubers” are central variables, for instance, for investigating the availability and accessibility of food, which maps on to studies that use anthropometric measures in their analysis. “Food Price Volatility” and “Cereal Import Dependency” are key variables in the large set of studies of how food prices and market shocks affect the outbreak of violence. One major problem, which we discuss later in the article, is data availability in the Utilization pillar; data coverage on percentage of children affected by wasting, stunting, and low weight is well under 50 percent across all countries and years. In this section, all variables are annual measures taken at the country level. The five food security variables are defined as follows:

- “Prevalence of Undernourishment” is the percentage of the population suffering from undernourishment. This data is reported from 1993–2014, and for each year it measures the average of the previous three years. It is the primary food security indicator used by FAO as part of the monitoring process for Target 2.1 of the Sustainable Development Goal (SDG) 2, and thus should be a starting point for understanding a general relationship between food security and conflict.
- “Depth of Food Deficit” is an index number representing the difference between consumed calories and the necessary number of calories to reach an intake that would alleviate undernourishment.
- “Share of dietary energy supply derived from cereals, roots and tubers” represents the percentage of caloric intake made up of cereals, roots, and tubers. Evidence from conflict research shows that conflict can affect food production and adaption strategies.
- “Food Price Volatility Index” represents volatility of food prices domestically in a country for 2000-2014. This variable is important since there are many findings that tie price shocks to violence.
- “Cereal Import Dependency Ratio” represents the ratio of imports versus domestically produced cereals. Like price volatility, a country that must import food is exposed to price shocks and thus could presumably be at higher risk of violence.

Figure 2. Trends in food security, 1993–2014



Source: Data from FAO (2017) database.

In Figure 2 we see a generally positive pattern where food insecurity has decreased globally between 1993 and 2014. The timeline of 1993–2014 is selected based on data availability in the FAO food security database at the time of writing. The primary indicator that the FAO used to measure success in reducing hunger, Prevalence of Undernourishment, shows a distinct downward trend. We excluded Depth of Food Deficit in the graph since it uses a different scale than the other variables, and it has a trend that is derivative of Undernourishment. We will look at it later in the paper when we unpack endogeneity concerns.

2.3 Endogeneity concerns

In an ideal setup to study causal links in between food security and violent conflict, we would like to observe two identical populations simultaneously. For instance, only one of the two populations is "treated" with violent conflict, and we then compare food security outcomes between the treated and the non-treated population. As identical populations do not exist, estimations of such comparisons between treated and non-treated populations are not straightforward. Essentially, the central empirical challenge is to identify plausibly comparable populations, where treatment is "as good as random". The main statistical threat in pinning down a causal effect violent conflict to food security and vice versa is endogeneity bias.

The two principal sources of endogeneity are unobserved confounding factors and reverse causality. For instance, for many forms and circumstances of food insecurity one can think of a range of factors that simultaneously drives food insecurity and the likelihood of violent conflict. If such a factor that is correlated with both conflict and food security is erroneously not included in the specified model of a food insecurity measure, the estimate of the impact of violent conflict will be biased. Similarly, a snapshot of food insecurity in region X at time T may be driven by violent conflict in region X at time T, while at the same time the violent conflict may actually be

the result of the food security on region X. A large body of cross-country evidence suggests that national income is negatively correlated with the incidence of violent conflict (Blattman and Miguel, 2010). Table 1 shows the food security scores for countries batched by their 2014 income group according to the World Bank (World Bank, 2017). With the exception of Cereal Import Dependency Ratio, food security improves at each progressive step from low- to high-income countries. These strong patterns show that national income is not only intimately related to the incidence of conflict but also to various pillars of food security.

Table 1. Averages of food security indicators by income group, 2014

	Food Security Indicator Averages, most recent year reported by FAO				
	Prevalence of Undernourishment (2014)	Depth of Food Deficit (2014)	Percent Cereals/Roots/Tubers (2014)	Food Price Volatility Index (2014)	Cereal Import Dependency Ratio (2009)
Low-income countries	25.56%	191.71	65.21%	9.77	24.95
Lower-middle income countries	13.95%	97.88	53.64%	7.87	34.81
Upper-middle income countries	10.30%	67.55	44.50%	7.29	31.22
High-income countries	5.31%	22.16	33.17%	6.98	24.79

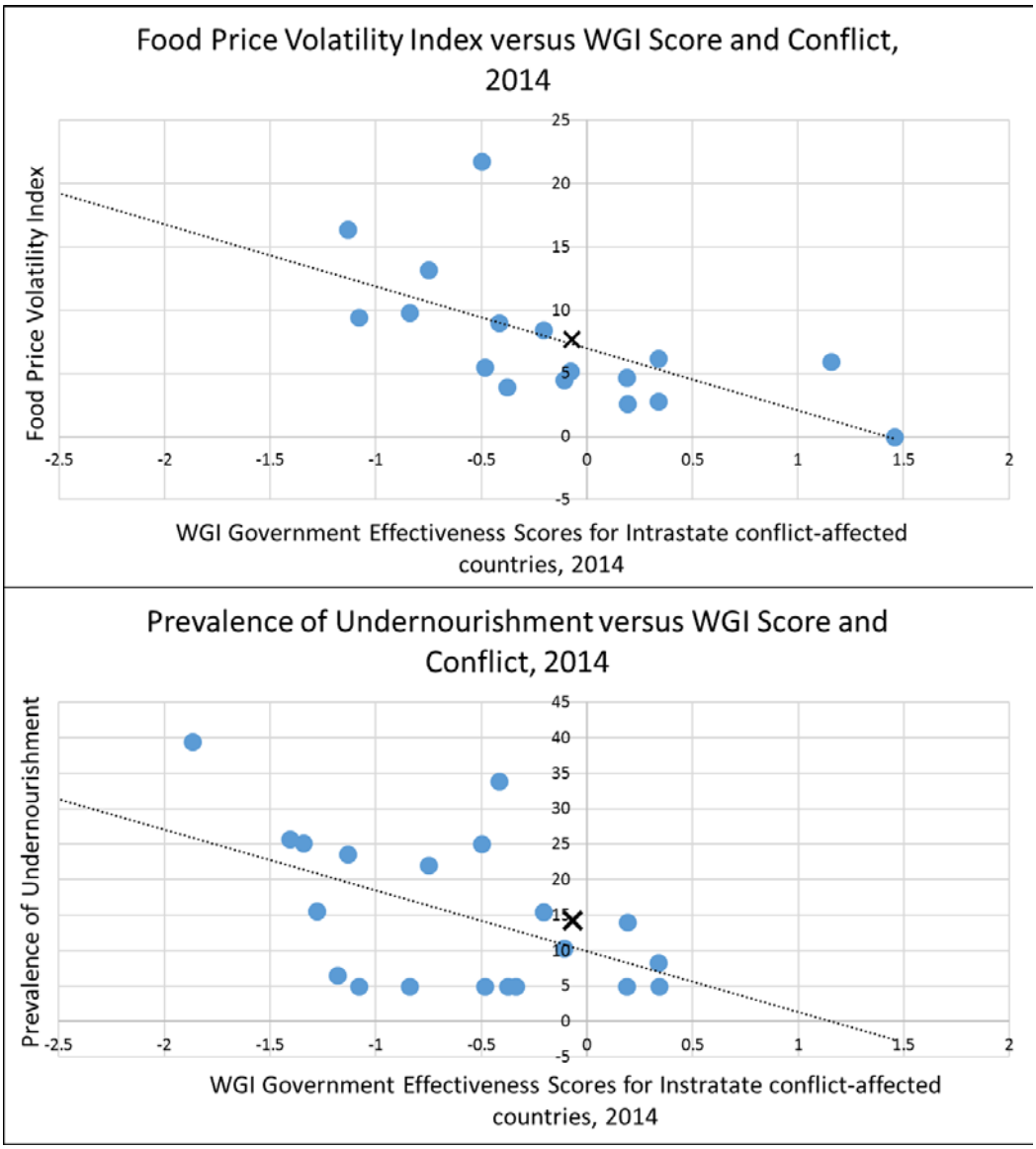
Note: Larger numbers indicate lower food security.

Source: Income groups from World Bank (2017) data, food security data from FAO (2017) database.

The function of the state goes beyond just economic performance in the form of national income, and the second factor we look at is national administrative capacity. The incidence of violent conflict is often per construction a symptom of state weakness, such as in civil wars where the state lacks the capacity to monopolize central violence and control over the whole of its nominal territory. Notably, though, some countries affected by internal conflict actually score reasonably well in the World Bank's World Governance Indicators (WGI).

Figure 3 shows a basic representation of how the WGI Government Effectiveness Scores (an index of public administration quality) is related to food security outcomes in countries affected by Intrastate conflict in 2014. Food price volatility and prevalence of undernourishment become noticeably worse in as quality of public administration diminishes.

Figure 3. The relationship between WGI score and food security among Intrastate conflict-affected countries



Note: Larger numbers on the Y-axes indicate greater food insecurity.

Source: Data from FAO (2017) and World Bank (2017).

Figure 3 shows that as government effectiveness increases in these contexts food security outcomes improve (on average). These strong patterns show that, like national income, state capacity is not only intimately related to conflict outcomes but also to various pillars of food security. Given that we discussed five indicators previously, it would be fair to ask why we only look at two in the graphs above. This is largely a problem of data availability and matching. For example, the timeline for Cereal Import Dependency Ration stops in 2009. In 2014, when we filter for only countries affected by interstate conflict that also report food security data and have WGI scores, we are left with 17 countries reporting Food Price Volatility and 19 reporting Prevalence of Undernourishment. These kinds of missing data issues will be discussed in more detail in section four.

3 The causal relationships between food security and conflict

This section reviews robust findings from quantitative analyses of the bi-directional relationship between food security and violent conflict that account for endogeneity concerns. We summarize the existing evidence and identify limitations in both directions: (i) the impacts of violent conflict on food insecurity in Section 3.2 and (ii) the impacts of food insecurity on violent conflict in Section 3.3. The scope of the review is deliberately broad to reflect the spectra of different forms of food security and conflict. While we focus on *findings* (that are supported by strong empirical evidence), we sometimes highlight specific studies in more detail if they broke new ground, introduced a technique, raised new questions or provided important or even controversial nuances to a broader finding. Sections 3.4 and 3.5 summarize the relatively recent and controversial ─ but highly policy-relevant ─ debates about the causal effects of climate conditions and food policies on food security and violent conflict and their interrelationships. Section 3.6 reflects on the dominant strategies researchers have used to identify causal relationships between food security and conflict and discusses methodological gaps.

3.1 The impacts of violent conflict on food security

It is well established that differences in food security shape short-term and long-term outcomes of health and well-being, when the ability of individuals and nations to cope with shocks and to smooth income and consumption is limited. In conflict-affected countries, many households and firms are smallholder farmers, who face a high degree of income uncertainty even in the absence of conflict, primarily through weather shocks (Townsend, 1994; Maccini and Yang, 2009). Some are commodity suppliers to local, domestic or global markets, such as cocoa or coffee farmers, who are also subject to price fluctuations in these markets (Deaton, 1999; Kruger, 2007; Miller and Urdinola, 2010; Adhvaryu, Kala and Nyshadham, 2015; Adhvaryu, Fenske and Nyshadham, 2016). In this case, conflict presents an additional 'shock' that affects the livelihoods and well-being of these populations. Two important points are apparent. First, the nature of this 'shock' may be quite diverse across different types and intensities of armed conflict and across the national and local institutions that are either transformed or emerge during this armed conflict (see also Justino, 2012). Second, exposure to conflict may directly shape food security, but also interact with other fluctuations, such as those in prices and climatic conditions.

3.1.1 The impacts of violent conflict on nutritional status

A large literature has identified adverse short-term effects of exposure to conflict on children's nutritional status. Most evidence exists for anthropometric outcomes, which are directly associated with nutritional status. These are primarily the height-for-age Z-score (HAZ), i.e. height conditional on age and gender, and assessing 'stunting', which is growth failure in a child that occurs over a slow cumulative process. As stunting reflects episodes of sustained undernutrition, low scores are associated with 'chronic malnutrition'. A second indicator is the weight-for-age Z-score (WAZ), i.e. weight conditional on age and gender. Low WAZ scores are associated with 'general malnutrition'. Third, weight-for-height measures or 'wasting', are often considered the most robust indicator for 'acute malnutrition'.

Most analyses rely on a difference-in-differences approach pioneered by studies from Rwanda and Burundi. In Burundi, Bundervoet, Verwimp and Akresh (2009) show that children aged 0–5 who were born in regions affected by civil war violence, have significantly lower HAZ scores than those born in other regions. Follow-up studies report consistent, adverse effects on anthropometric outcomes among children from a range of conflict-affected contexts, including Angola, Colombia, Cote d'Ivoire, Eritrea, Ethiopia, India, Iraq and Mexico (Arcand, Rodella and Rieger, 2015; Duque, 2016; Minoiu and Shemyakina, 2014; Akresh, Lucchetti and Thirumurthy, 2012; Akresh, Caruso and Thirumurthy, 2016; Tranchant, Justino and Müller, 2014; Guerrero-Serdan, 2009; Nasir, 2016). Akresh, Verwimp, and Bundervoet (2011) find very similar effects of civil war violence on child stunting in northern Rwanda and contrast the effects with those of a contemporaneous crop failure in southern regions, that was *not* induced by conflict. The analysis finds important differences between the conflict and non-conflict shocks. War exposure affected all children equally, while only girls were negatively affected in the case of crop failure. This result suggests that boys' could smooth their consumption during crop failure families, while girls were not able to do so during conflict exposure.

The magnitudes of the adverse effects of exposure to armed violence on anthropometric outcomes are markedly similar across case studies and contexts, despite significant differences in conflict duration, war strategies and other context-specific characteristics. Yet, two key limitations of the current literature remain. First, poor nutritional status is often directly linked to food insecurity. However, a person's nutritional status may or may not be the result of food insecurity, i.e. due to lack of access to sufficient, safe and nutritious food (access defined as physical, social and economic). Second, most of the rigorous and robust evidence documents adverse effects in chronic malnutrition, rather than acute malnutrition. However, acute malnutrition indicators in particular are critical measures. These should be closely monitored and analyzed in conflict and protracted crisis countries as well as serve as a key source of information for humanitarian interventions. Thus, more rigorous evidence on the impact on acute malnutrition is of paramount importance.

A related body of evidence shows that adverse short-term effects of conflict on children through nutritional channels may already be activated before a child is born ('*in utero*'). Pregnant women who are exposed to more conflict give birth to children of lower weight, which thus immediately transmits adverse effects of conflict across generations. The pioneering study by Camacho (2008) finds that the exposure of women to violence across Colombia during the first three months of pregnancy resulted in lower birth weights. These effects have been confirmed by findings from diverse contexts, such as Brazil, Mexico, Nepal, Kashmir and Palestine (Foureaux Koppensteiner and Manacorda, 2016; R. Brown, 2015; Valente, 2011; Parlow, 2012; Mansour and Rees, 2012).[1] While the relationship between conflict exposure in utero and birth weight is robust, questions about the underlying mechanisms – which are likely to be highly context-specific – and the impacts on measures such as height as a child are hitherto only inconclusively debated (Akresh, 2016).

[1] While the reduced-form link is very robust, it is worth noting that disentangling nutritional channels from others, such as effects of maternal stress that do not work via nutrition, empirically is very difficult.

3.1.2 Long-term consequences of early-life exposure to conflict

The famous 'fetal origins hypothesis' posits that variation in access to nutrition in the womb codes long-run differences in health and well-being. The original hypothesis has been extended to early-life nutrition after birth and confirmed by a large body of empirical evidence, which is reviewed by Almond and Currie (2011) and Currie and Vogl (2013). Conflict exposure early in life, including nutritional deficiencies and other adverse experiences, may thus pre-determine detrimental long-term impacts, which threaten food security as an adult.

A few recent studies have started to produce robust support for damaging effects on physical and cognitive development outcomes as an adult have been reported from various other conflict-affected settings, e.g. Cambodia, Germany, Mozambique and Zimbabwe (de Walque, 2006; Akbulut-Yuksel, 2014; Domingues and Barre, 2013; Alderman, Hoddinott and Kinsey, 2006). The important study by Akresh *et al*. (2012) provides convincing evidence that the magnitude of adverse impacts may vary significantly by age at exposure 40 years after the end of the conflict. For instance, they show that women who had been exposed to the Nigerian civil war in Biafra between 0 and 3 years of age are, on average, 0.75 centimeters shorter than non-exposed women of the same age. Women who were exposed when they were 13 to 16 years old are 4.53 centimeters shorter than non-exposed women of the same age. These strong heterogeneities remain to be validated across other conflicts and contexts.

Taken together, the literature has rapidly accumulated a wealth of robust micro-evidence that the exposure to conflict at a young age is causally linked to irreversible harm to short- and long-run development from nutritional disadvantages. What aspect of violent conflict causes these immediate nutritional deficits, and how, remains not well understood, and is likely to include multiple and context-specific pathways. While a recent literature demonstrates that conflict may have detrimental long-run effects, it also remains to be understood how and how strong food security is affected. Specifically, conflict exposure may push children into a reinforcing cycle of food insecurity, where food insecurity at young age may eventually cause or contribute to compounding dietary health and food insecurity issues as an adult.

3.1.3 The impacts of violent conflict on coping and consumption

To better understand reactions to conflict exposure and associated impacts on outcomes related to food security, many economists have directly studied micro-strategies to reduce conflict risk and smooth consumption (Justino, 2009).[2] Descriptive evidence suggests that these strategies are dynamic and likely to differ at conflict onset and during protracted conflict (e.g. Ogbozor, 2016).

Many of the stronger findings describe migration and forced displacement, and document a wide range of adverse effects on food security. Several quantitative studies rely on refined household survey data related to the quantity and quality of consumption, despite the challenges to thorough data collection in these regions. Indicators include activity choices, detailed consumption diaries, resulting calorie intake data, food expenditures, food produced and food gifts combined with local food price data. However, teasing out and quantifying causal

[2] Especially for self-sufficient farmers, this obviously also concerns re-allocations of labor and capital in agricultural production, which we discuss later.

relationships is once again daunting and robust evidence is thus rare (see review in Ruiz and Vargas-Silva [2013]).

A few convincing studies validate and confirm the correlational evidence. For instance, Kondylis (2010) exploits differences in the timing of *return* of Rwandan internal refugees to establish that returnees are significantly better off economically than those who had (still) remained displaced. Bozzoli, Brück and Muhumuza (2016) produce meaningful comparisons of residents of internal displacement (IDP) camps in post-war northern Uganda and those who had just relocated from camps voluntarily. The study finds significant differences in activity choices. While camp residents are less active overall (which may suggest their productivity is low), they are more likely to cultivate and trade. Verwimp and Munoz-Mora (2013) find similar effects on food expense and calorie intake among Burundian refugees. The study estimates that it would take 8–10 years after return for the welfare gap between displaced and non-displaced households to close. These findings suggest that displacement may have strongly adverse long-term legacies, which – without assistance – may be impossible to overcome for the poorest populations.

Beyond displaced populations, other studies have investigated food consumption patterns in conflict zones more generally, and link them to conflict event data. As expected, the findings confirm that households living close to registered conflict events often experience drops in consumption levels in settings as diverse as Afghanistan (D'Souza and Jolliffe, 2013), Cote d'Ivoire (Dabalen and Paul, 2014) and Rwanda (Serneels and Verpoorten, 2015).

Beyond violence, an emerging literature offers descriptive evidence on the local presence and rule of armed state and non-state groups (Arjona, Kasfir and Mampilly, 2015). One the one hand, such groups often invest in local public goods (Sanchez de la Sierra, 2016), which may increase local consumption levels. However, one the other hand, food is essential for the survival of armed groups (e.g. Justino and Stojetz, 2016), which may decrease local consumption levels. At the extreme end of the spectrum, these processes also include scenarios where food and hunger are used as 'a weapon of war' (Messer and Cohen, 2015). Yet, collecting microdata on these processes is difficult, and to the best of our knowledge, these effects have not been studied and quantified systematically.

At aggregate levels, both direct and indirect studies of consumption are surprisingly scant. The early study by Teodosijević (2003) reveals that the experience of conflict between 1961 and 2000 is associated with a 7 percent reduction in daily energy supply among 38 countries. Jeanty and Hitzhusen (2006) find similar results based on 73 countries between 1970 and 2002. Gates *et al.* (2012) present perhaps the most extensive set of reliable estimates of the impact of conflict on food security and underdevelopment at the cross-national level. Key findings include that a conflict with 2500 battle deaths increases the share of population living on less than the minimum recommended dietary energy consumption by 3.3 percent, and denies an additional 1.8 percent of the population safe access to potable water.

3.1.4 The impacts of violent conflict on agricultural production

A separate literature looks at the impact of conflict on production of food, and factors which are fundamental to the production side of food security. A large body of studies has investigated the effects of civil war on (broad) economic production and growth across countries.[3] The impacts

[3] For a surveys on the economic costs of conflict see, e.g., de Groot, Bozzoli and Brück (2015).

of violent conflict on social, political and economic institutions (including markets) are likely to be among the important factors shaping heterogeneous responses to conflict. While the long-term effects on economic performance, including food production and food security, could be positive or negative, these are still among the least understood of all impacts of violent conflict (Blattman and Miguel, 2010). Overall however, institutional change, which characterizes most violent conflicts, and the impacts on food production remain very poorly understood, both at the national and the local levels.

A few recent studies have used innovative farm-level and conflict data as well as modern techniques to analyze the causal impact of violent conflict in East Africa and Colombia on agricultural production, including livestock and a variety of crops, such as coffee. The findings suggest that production may drop substantially in regions affected by conflict, due to adverse effects on labor supply, access to land and access to credit and/or direct effects on capital such as theft and destruction (Nillesen, 2007; Verpoorten, 2009; Rockmore, 2015; Munoz-Mora, 2016; Blattman and Miguel, 2010).[4] Observing actual micro-level responses to conflict exposure in situ is particularly challenging, but there is growing empirical evidence on the coping strategies of conflict-affected individuals and households to protect their productivity, livelihoods and food security. As for instance in Africa 70 per cent of the population rely on agriculture for their food supply (Paul, Shonchoy and Dabalen, 2015), the literature has focused on agricultural coping strategies. Well-documented strategies include shifts in crop production portfolios, labor reallocation, destroying or hiding livestock (and other visible assets), changes in land use patterns, economic cooperation with local ruling groups and other activities that minimize victimization risks and uncertainty (e.g. Bozzoli and Brück, 2009; Brück and Schindler, 2009; Verpoorten, 2009; Rockmore, 2011; Arias, Ibañez and Zambrano, 2012; Fernández, Ibañez and Peña, 2014; Gáfaro, Ibáñez and Justino, 2014; Menon and van der Meulen Rodgers, 2015).[5]

Several studies emphasize that shifts in crop, livestock and asset portfolios are often consistent with households increasing the share of low-risk, low-return activities (e.g. Vlassenroot, 2008; Justino, 2009; Paul, Shonchoy and Dabalen, 2015; Rockmore, 2015). These low-risk low-return coping strategies may obviously have adverse long-term consequences, but may also provide immediate and longer-term *benefits*. In terms of benefits, Brück (2003) and Bozzoli and Brück (2009), show that subsistence farming led to improvements in the economic security of households living in extreme poverty during the civil war in Mozambique, because social and economic markets entailed limited welfare benefits. However, these effects of subsistence modes of production during conflict must be balanced against the longer-term adverse effects of low productivity. In addition, the external validity of this finding is contested. For example, Nillesen and Verwimp (2010) show that many Burundian households exposed to high levels of conflict violence shifted their portfolios towards more sustainable, and more profitable, activities, and that income shares from export crop farming were higher in violence-affected regions (even though the causality may have run from export cropping to conflict in this case).

[4] We discuss the household- and farm-level decisions underpinning most of these results below.

[5] Notably, some of these strategies differ from findings from reactions to non-conflict shocks. For instance, selling − rather than hiding or destroying − livestock, is documented as a common form of coping strategy used by rural households in developing countries in times of crisis.

3.2 The impacts of food (in)security on violent conflict

The broad field of food security and its consequences has attracted wide attention by academics and practitioners recently. Analyses have predominately focused on a conceptual understanding of food insecurity, such as the lack of dietary energy availability and nutrient deficiencies, and how to alleviate these concerns. While a large body of literature has studied the impact of broad categories of economic and ethnic differences, such as in growth or religion (for a recent review see Ray and Esteban, 2016), researchers and practitioners have only recently started to study the consequential impacts of food insecurity on conflict comparatively and rigorously (for a broad overview and excellent analysis on the effects on the occurrence of conflict see, e.g., Koren and Bagozzi, 2016).

Two important points are obvious. First, food security aspects relevant for conflict zones and societies may be very diverse and vary substantially across different types and intensities of armed conflict and income levels. Second, impacts originate from and operate at very different levels. At the individual and household levels, factors such as nutrition and economic opportunity may directly affect participation in virtually any form of anti-social behavior. A range of additional mechanisms may originate at more aggregate levels, including global food prices and policies as well as domestic and local wartime institutions, markets, governance and climatic conditions.

3.2.1 The impacts of food insecurity on anti-social behavior

At the individual level, food insecurity ─ or the threat thereof ─ may create both material and non-material incentives for individuals to engage in some form of behavior that threatens peace (to which this section will refer to as 'anti-social behavior'). Pinning down a single channel empirically is extremely difficult, however, and rigorous empirical evidence at the individual level is therefore markedly thin. Two key challenges are that these motives are a) in and of itself very complex and hence difficult to measure and b) empirically extremely difficult to untangle from alternative mechanisms that are often credibly not directly related to food insecurity, such as abduction, peer-pressure, ideology, and emotions. The pioneering studies of ex-combatants by Humphreys and Weinstein (2008) provide perhaps the most compelling empirical evidence. Based on original survey data they show that armed groups sometimes target recruits via basic needs, by providing food, shelter and physical security.

More recently, a growing number of qualitative accounts have emerged that document how civilians survive and protect their livelihoods and food security through forms of support for armed groups, which may be voluntary or involuntary. These processes are endogenous to 'wartime governance' by local ruling groups and underline the centrality of shelter, food and information to the fate of armed groups (Wood, 2003; Kalyvas, 2006; Arjona, Kasfir and Mampilly, 2015; Justino and Stojetz, 2016). However, it is apparent that rigorous evidence beyond descriptive and qualitative analyses is very scarce.

3.2.2 The impacts of food prices shocks on violent conflict

Historical accounts are replete with descriptions of how rising food prices breed violent conflict, including insurgencies, wars and revolutions (Rudé, 1964; Goldstone, 1991; Diamond, 2005). There is now a growing body of econometric evidence ─ broadly in the vein of Hendrix, Haggard and Magaloni (2009) ─ that supports this conjecture for the incidence of very different forms of

social unrest, such as protests, riots, violence and war, with most studies relying on the FAO price index of food commodities.

Most evidence exists for urban social unrest in contemporary Africa (e.g. Berazneva and Lee, 2013; Smith, 2014), which includes studies linking the 'Arab Spring' uprisings to international food price shocks (e.g. Johnstone and Mazo, 2011; Maystadt, Trinh Tan and Breisinger, 2014). More recent findings suggest global relevance (Bellemare, 2015; Cadoret, Hubert, and Thelen, 2015). Studies of the intensive margin of violent conflict are more scarce, but point to broadly similar, positive relationships with increasing food prices (see e.g. Breisinger, Ecker and Trinh Tan, 2015; Maystadt and Ecker, 2014). By contrast, much less is known on how and how much food prices drive violent conflict. Among the most fundamental unsettled questions is whether and when it is the level versus the volatility of food prices that breeds conflict. In this regard, the most convincing evidence is provided by Bellemare (2015), who forcefully argues that increases in food price levels cause urban unrest, while those in food price volatility do not.

The dominant explanation for the food price-conflict link are consumer grievances; higher prices essentially create or increase economic constraints and/or sentiments of perceived relative deprivation, which activates grievances that in turn lead to conflict. This causal chain is very difficult to both measure and isolate empirically, for reasons already noted above, which is why it is usually assumed rather than tested directly. In addition, most contributions have looked at the impact of international food prices on conflict at the national level, which is reasonable in principle, as many fragile and conflict-affected countries are net importers of food. However, a few recent studies emphasize the need to use country-specific food price indexes to better understand the consumption patterns and constraints faced by vulnerable populations (e.g. Arezki and Brueckner, 2014; Cadoret, Hubertt and Thelen, 2015; Weinberg and Bakker, 2015). In an innovative study using such an approach based on a country's food import pattern, Van Weezel (2016) provides three statistically robust and important findings:

- The (previously documented) relationship between food prices and urban conflict is driven mainly by the prices of basic staples like wheat;
- It is also predominantly supported for high-intensity conflict;
- Interestingly, however, the magnitude of the effect as well as the predictive power of food prices are both notably moderate.

A second set of explanations for the food price-conflict link emphasizes breakdowns of state authority and legitimacy, when the state fails to provide food security, i.e. activating grievances against the state (e.g. Lagi, Bertrand and Bar-Yam, 2011). A few recent analyses have sought to document the related impact on state-level correlates of conflict. For instance, Arezki and Brueckner (2014) argue that the cohesiveness of political institutions in low-income countries deteriorates significantly when international food prices increase, while Berazneva and Lee (2013) show that rising food prices and riots in Africa are associated with more political repression.

3.2.3 The impacts of food production on violent conflict

While many developing countries ─ especially in Africa ─ increasingly rely on food imports for domestic consumption, agriculture often remains the largest economic sector, delivering labor opportunities and sustaining livelihoods. A third large strand of literature thus focuses on the

role of variation in food production on violent conflict. As food production is strongly dependent on climatic conditions in many developing countries, new evidence is emerging on food production variation induced by climatic fluctuations, which is reviewed separately in the next section.[6]

Decreases in labor demand due to shifts in agricultural production may directly lower the opportunity cost of engaging in anti-social behavior (Miguel, Satyanath and Sergenti, 2004). For instance, Guardado and Pennings (2016) show that conflict intensity in Iraq and Pakistan is higher outside the harvest season, when demand for labor in agriculture is lower. More generally, decreases in agricultural productivity may directly activate societal grievances due to increasing destitution, famine, distress, migration or aggravated social inequalities (Barnett and Adger, 2007; Raleigh and Kniveton, 2012; Kelley *et al*., 2015; Reuveny, 2007; Raleigh, 2010). A third source of violent conflict discussed in the literature are increased grievances against the state, when agricultural deficits at the state level result in losses of tax revenues and higher food prices, as discussed above (Homer-Dixon, 1999; Kim, 2016). In this case, associated forms of maldistribution, patronage, corruption and embezzlement of aid may then also activate or exacerbate existing grievances against the state (Benjaminsen, 2008; Hendrix and Brinkman, 2013; Nunn and Qian, 2014).

From a production point of view, increased international commodity prices ─ including agricultural commodities ─ could benefit domestic producers of the commodity and reduce conflict, for instance by an increase in opportunity costs (see e.g. Bazzi and Blattman, 2014). On the other hand, conflict could also become more likely, when, for instance, economic pay-offs to violent capture of agricultural revenues rise (see e.g. Fjelde, 2015). These basic considerations suggest that fluctuations in commodity prices may affect subpopulations and sub-regions in conflict zones very differently. While of paramount importance, researchers have just begun to develop rigorous studies and frameworks to analyze these processes empirically. A few recent contributions provide initial but statistically very sound insights. McGuirk and Burke (2016), for instance, demonstrate empirically that increases in world commodity prices can reduce the incidence of large-scale conflict over land and the control of territory ('factor conflict') for African food-producing grid-cells. Conversely, higher prices can increase the incidence of (small-scale) conflict over the appropriation of surplus ('output conflict'). The innovative study by Crost and Felter (2016) combines global market prices with spatial variation in crop intensity in the Philippines to show that increases in major export crop can causally exacerbate violence. The effects are driven by insurgents gaining strength by extorting agricultural exporters. Related, Wright (2016) shows how Colombian rebel tactics respond to fluctuations in world coffee and coca prices. Drops in coffee prices allow and cause rebels to use more intense conventional fighting (as economic opportunities outside of rebellion are argued to be low), while dropping returns to coca production lead to irregular rebel attacks (as rebels are argued to be more resource constrained). Finally, concerns of securing local food access and smoothing food security of its members can also make armed groups more likely to perpetrate violence against civilians when intergroup conflict activity is high (Koren and Bagozzi, 2017).

[6] In Africa, for instance, merely 6 percent of the all food production is irrigated (NEPAD 2013).

3.3 Climate change, food security, and conflict

A related and burgeoning literature focuses on the quantitative links between variation in climatic conditions and conflict (see, e.g., the recent review by Burke, Hsiang and Miguel [2015]). The impact may be substantiated by multiple pathways, some of which are closely related to food security and include those operating via economic conditions and outcomes.

Most attention in the literature has focused on assessing whether empirical estimates of the purported 'reduced-form' link between climatic variation and conflict outcomes are spurious and have a causal interpretation. Studies from numerous settings find that both above-average temperatures and below-average precipitation levels are positively associated with conflict onset and duration, starting with an influential analysis on temperature and civil war incidence by Burke *et al.* (2009). Others have contested the existence of this relationship and highlight that such a conclusion may be flawed, due to measurement error, data set selectivity and methodological strategies (Buhaug, 2010a; Buhaug, 2010b; Sutton *et al*., 2010). Yet, the leading perspective nowadays is that the climate-conflict link is real (Burke, Dykema *et al*., 2010; Burke, Miguel *et al*., 2010a; Burke, Miguel *et al*., 2010b), which is backed up by recent meta-analyses of 50+ prior studies documenting substantial effects of temperature increases on the likelihood of interpersonal and intergroup conflict (Hsiang, Burke and Miguel, 2013; Burke, Hsiang and Miguel, 2015). This also includes increases in conflict violence against civilians (Vanden Eynde, 2015).

Beyond the basic debate on the existence of the climate-conflict link, two observations from this relatively recent literature are worth noting. First, existing studies have nearly exclusively focused on sub-Saharan and Sahelian regions in Africa. Second, there is a very active debate about whether and how the effect of climate on conflict operates through local economic conditions. The focus on this specific pathway is partly driven by the interest in understanding the effect of economic conditions on conflict, as noted above. The first step in the chain of causation via local economic conditions is that unusually high temperatures and low rainfall depress agricultural production and output, which is not disputed for Africa (e.g. Barrios, Ouattara and Strobl, 2008; Schlenker and Lobell, 2010).

While the intuitive link with an associated drop in food security is often essentially assumed, a number of studies have explicitly documented negative impacts of climatic variation on household food security (see, e.g., for Ethiopia see Dercon and Krishnan, 2000; Demeke, Keil and Zeller, 2011; Di Falco, Veronesi and Yesuf, 2011).

In a second step, diminished agricultural yield and incomes are theorized to drive conflict by affecting local employment opportunities, prices, and grievances. Subsequent studies have thus sought to predict the consequences of climate change on violence levels by extrapolating from historical temperature and rainfall trends in rural Africa (e.g. Gleditsch, 2012; Hendrix and Salehyan, 2012; Raleigh and Kniveton, 2012; Theisen, 2012). Yet, the mechanisms substantiating this second step remain largely untested empirically. Raleigh, Choi and Kniveton (2015) not only demonstrate the complexity of these relationships and the difficulty to untangle them empirically, but also provide rare convincing evidence of how the link from climatic variation to conflict can flow via food prices.

Recent research points to alternative mechanisms of how temperature anomalies may be related to conflict. Temperature-induced variation in agricultural yield can alter migration patterns, with potential effects on sub-state violence and conflict (Salehyan and Gleditsch, 2006; Hsiang, Meng and Cane, 2011; Feng, Krueger and Oppenheimer, 2010; Feng, Oppenheimer and Schlenker, 2012; Bohra-Mishra, Oppenheimer and Hsiang, 2014). Excessive heat may also reduce the broader supply of crops, raising the price of food (see above). Temperature anomalies also have effects on economic activity beyond agricultural production. Several studies have documented that higher temperatures may depress economic output and growth, which may lead to conflict (Hsiang, 2010; Jones and Olken, 2010; Dell, Jones and Olken, 2014; Carleton and Hsiang, 2016). While these economic factors may well be linked to food security, empirical psychological research at the individual level has long established the tendency of individuals to behave more violently due to higher temperatures (Burke, Hsiang and Miguel, 2015). These mechanisms are likely to interact with conflict risks due to food security and it is also possible that food security-based mechanisms are weak or even absent. The recent study by Bollfrass and Shaver (2015) provides an interesting finding. Using new global data at the provincial level they document the universal existence of a temperature-conflict link, which it also obtains in regions without agricultural production.

The bulk of the (markedly inconclusive) empirical studies linking precipitation and violent conflict aggregates rainfall during calendar years and over the totality of a country's territory. The recent paper by Maertens (2016) focuses on agricultural cells and explicitly incorporates the economics of agricultural production, i.e. that there is a non-linear relationship between rainfall and agricultural output. The study demonstrates that the hump-shaped relationship of rainfall and output in agricultural cells translates into a u-shaped relationship between rainfall and civil conflict risk at the country level. A substantial increase at comparably low levels of rainfall reduces the risk of civil war onset, while the same shift occurring above a certain threshold in levels *increases* the risk of civil war onset.[7]

3.4 Food security policies and violent conflict

With respect to policy interventions related to food security, arguably the most prominent literature is a broad body of empirical studies analyzing the impact of foreign aid and assistance on conflict outcomes. This literature is clearly very important, but it is also one of the most controversial ones in the fields of development and conflict. Theoretical models suggest that the welfare effects of material aid in fragile and conflict-affected settings is broadly ambiguous, depending on factors such as the 'cohesiveness' of political institutions and the level of government capacity, while technical assistance if effective should reduce conflict (Besley and Persson, 2011). The key empirical issue is that aid assistance is not randomly allocated. The existing evidence from both within as well as from across countries is markedly mixed. Depending on the measures used, the level of aggregation, the empirical strategy employed

[7] For related recent contributions on the two-step effects of precipitation anomalies, including droughts and floods, see also Buhaug *et al.* (2015), Ghimire, Ferreira, and Dorfman (2015) and von Uexkull *et al.* (2016). Another example of a study of a wide range of rainfall levels is Hidalgo *et al.* (2010), which documents a strongly non-linear relationship between rainfall and land invasions in Brazil.

and the context, results range widely from very negative to very positive impacts of aid on conflict (see e.g. Galiani *et al*., 2016).[8]

The statistically most robust and most direct evidence on conflict outcomes stems from a few recent studies that use new high-quality data and exploit natural or randomized variation in certain types of foreign aid to identify its causal effects. Perhaps less intuitive findings include that conflict risks increased due to U.S. military aid in Colombia (Dube and Naidu, 2014), due to U.S. food aid to low-income countries (Nunn and Qian, 2014) and via community-driven development aid in the Philippines (Crost, Felter and Johnston, 2014).

Beyond aid, it obvious that many subnational interventions related to food security, including in conflict-affected settings, exist, and many have successfully relieved food security stresses. While surveying these is beyond the scope of this section and deserves an entire literature review, the actual impacts of improved food security status on reducing conflict risk appear to be highly context-specific and are often assumed rather than tested rigorously. This encompasses various forms of food security and also includes innovative policies that build resilience (e.g. Breisinger *et al.*, 2014).

3.5 Identification strategies

From a methodological perspective, various modern econometric approaches have been developed and employed to deal with concerns of statistical endogeneity affecting the relationships between food security and violent conflict. These strategies have contributed to establishing a diverse set of unidirectional effects that have a causal interpretation. In the wake of the so-called 'credibility revolution' in development economics (Angrist and Pischke, 2010), more reliable quantitative findings are concerned with micro-level processes and draw on new research designs built around plausibly exogenous variation in treatment, or factors related to treatment, from natural or controlled experiments.

Most existing empirical strategies dealing with endogeneity concerns fall into one of four categories. We briefly discuss the basic idea behind and examples of each category:

- **Selection on observables:** This approach seeks to make different populations 'nearly identical' to one another in all respects except their treatment status, usually after regression adjustment for observable economic, social and political variables. Examples include simple cross-sectional analysis, matching and synthetic control techniques.
- **Observation of same units over time:** This approach seeks to observe the same population over time, especially before and after treatment. Examples include simple panel data analysis, panel data analysis with lagged treatment and panel data analysis with lagged outcome variables.
- **Exogenous variation in treatment status:** This approach seeks to exploit plausibly randomized variation in the treatment of interest so that its causal impact can be evaluated. Examples include natural experiments (assignment by nature) and controlled experiments (assignment by experimenter).

[8] For an example that demonstrates that food aid can alleviate food insecurity at the household level see, among others, Tusiime, Renard and Smets (2013).

- **Exogenous variation correlated with treatment status:** This approach seeks to exploit plausibly exogenous variation that is *correlated* with variation in the treatment. Examples include instrumental variables (IV) and regression discontinuity designs (RDD).

Limitations

Among others, three critical, methodological gaps are apparent. First, less progress in terms of identification has been made at the macro level compared to the micro level, which, at least to some degree, has contributed to the fact that existing macro-level results are often markedly mixed and inconclusive. At aggregate levels, randomized experiments are harder to implement and natural experiments slightly more difficult to come across. Yet, natural experiments are increasingly and convincingly employed in macroeconomic studies (Fuchs-Schündeln and Hassan, 2015), and should be leveraged more in the study of the link between food security and conflict.

Second, identifying the effects of violent conflict at any level remains a central challenge. One of the reasons is that experiments where the conflict treatment itself is manipulated manually are not available. While a few innovative and sometimes `fortunate` research designs have exploited panel data in combination with plausibly exogenous conflict shocks, the toolset remains limited.

Third, identifying the effects of climatic conditions remains another central challenge, despite the wealth of recent scholarship. Like conflict, climatic conditions can (basically) not be randomized. In contrast to conflict exposure, the main statistical concern with differential exposure is less that certain units are `selected` based on their pre-treatment characteristics, but rather that climatic conditions often affect a myriad of factors that could lead to conflict (Dell, Jones and Olken, 2014). As more and more of such pathways are explored, widely used techniques such as using local rainfall as an instrumental variable for local economic conditions in rural areas (Miguel, Satyanath and Sergenti, 2004; Sarsons, 2015) have become increasingly less credible. This therefore emphasizes the need to improve existing techniques to identify the effect of food security on conflict.

4 Building evidence and policy: data issues and possible solutions

As the literature review shows, there is robust research that shows different causal relationships between food security and conflict, as well as new avenues for understanding food security and conflict dynamics that are still emerging. To get the most value out of this scientific research though, it is important to assess the practical issues that emerge when translating scientific results into practice, especially in terms of gathering national-level data for policy makers. As increased policy focus turns toward the peacebuilding effects of food security, we highlight data issues as well as innovative ways by way of which policy organizations can work around them.

4.1 Key data issues

Studying how food security and (the absence of) conflict are related is difficult if the data is of poor quality or missing, especially for important cases of conflict-affected countries. We illustrate different aspects of missing data on the basis of three examples of FAO food security variables. The first variable is Prevalence of Undernourishment, which has broad year to year global coverage. The problem with this variable is that specific countries are missing in the data and coincidentally these are countries affected by conflict (Libya, Sudan, Somalia, South Sudan, the Democratic Republic of Congo, and Syria); their exclusion means that we have no timeline to measure food security relative to changes in the intensity of their conflicts.

The second two variables we look at in the FAO's food security data are Percentage of children under 5 years of age affected by wasting, and Percentage of children under 5 years of age who are stunted. These kinds of anthropometric measures have been used in micro-level studies effectively, showing how conflict leads to food insecurity at the household and community level (e.g. Bundervoet, Verwimp and Akresh, 2009). The problem is that at the cross-national level the coverage for these variables is under 50 percent, and there are almost no timelines in the data. For example, in the Democratic Republic of Congo from 2000–2016 there are only observations of Wasting in 2001, 2007, 2010 and 2013. This kind of sparsity exists throughout both of the datasets on wasting and stunting, for all countries, making cross national analysis of a class of variables that have proven robust at the micro level impossible. Without more consistent annual data on anthropometric food security outcomes, it will be difficult to address the still-opaque causal channels highlighted at the end of Section 3.1.

The main challenge that researchers and policy makers have to deal with in the FAO data, and any data reported to an international organization, is that the data is aggregated at the national level. The more robust scientific research uses sub-national samples, tailored surveys, and proxies for food security such as height and growth scores to understand the effect of conflict on food security and vice versa. For many policy makers, these types of data collection and analysis processes are not practical day-to-day. We can refer back to Section 2 for an example of missing data as it affects a practical issue. In Figure 3 we could only use data for 2014; the only year for which there was enough aggregation of intrastate conflict-affected countries that reported both WGI and FAO data. This is a challenge that is unlikely to fundamentally change; the FAO relies on member states to contribute data, and this data will inherently be aggregated at the national level.

This points to a political issue. Unless wealthier member states help with things like funding and capacity gaps in the statistics offices of conflict-affected states, the data that does reach the FAO is going to reflect a state's ability to gather, clean, and share it. This kind of administrative burden may be beyond the capacity of a conflict-affected state, which means that national level numbers may inherently have limited analytic value when looking at the relationship between food security and conflict.

4.2 Innovation in data collection

The political science and economics fields have recently made significant strides in understanding the relationship between food security and conflict, particularly using microdata and sub-national survey methods. To bridge many of the conceptual gaps that emerge in cross national analysis, though, the institutional and country-level data needs to more effectively reflect the theoretical pathways between food security and conflict. This could include matching levels of analysis between phenomena, or by collecting purpose-built data. As increases in data collection capacity and new tools for analyzing geographic or qualitative data take shape, we should expect to see better and more broadly available data available through both the FAO and large-scale university-based data programs.

There are exciting possibilities in data collection, especially with regard to digital technologies, that can help offset the costs and time required to gather fine grained or specialized data. Mobile phone-based surveys have been shown to return reliable data, though there are still challenges in reaching rural populations and a noted issue with getting responses from female respondents (Leo *et al*., 2015). Improvements in both voice and SMS text message-based sampling could be used in specific cases where researchers or policy organizations need to collect large volumes of data from specific countries.

The scientific usefulness of text message and voice surveys using mobile phones is still in early phases of testing but initial results have shown promise. Leo *et al*. (2015) showed that in poor countries, especially Afghanistan and Zimbabwe, mobile phone based surveys were useful in reaching the poorest communities; phone credit incentives were helpful in preventing sample attrition as well. Leo and Morello (2015) followed this up with specific surveys on development policy preferences among respondents in poor countries, and found that mobile phone-based approaches were useful in gathering snapshot data of citizens' policy priorities. There are also other ways beyond surveys to collect data from mobile phone systems when working on food security and conflict. The World Food Program (WFP) has been using mobile cash transfer systems in its internally displaced peoples' camps in Cameroon, so that people can buy food they want from local vendors in a secure way (WFP, 2016). This is not only good for individuals, but can provide information about what kind of food people are buying, and data on prices and spending. Mobile phones provide both a means to do formal survey work in hard to reach places, and the meta data they produce in programs like cash transfer arrangements can tell an empirical story as well.

Geospatial technology and data is also an area that could prove useful in analyzing the relationship between food security and conflict. Brück *et al.* (2016) use Geospatial Information Systems (GIS) methods to analyze the relationship between food security indicators and events of violence in Ethiopia and Somalia, and data programs including UCDP and the Armed Conflict Location and Event Dataset (ACLED) are increasingly able to locate the place and time of violent

events. Finding ways to geographically define food security indicators could open new opportunities for spatial analysis of conflict and food insecurity. In many cases, mobile phone data can be geotagged to the cellular tower it originated from, making SMS text message surveys potentially temporally and geographically easier to match to event data. Sensing and imaging can also be used to understand macro trends in access to resources and conflict and may uncover new and sometimes counter-intuitive insights. For instance, remote sensing data allowed researchers to estimate ISIS revenues from crop production (Jaafar and Woertz, 2016) and revealed that in years prior to conflict outbreak in Darfur vegetation growth had actually been higher than normal (Brown, 2017), challenging arguments that fighting is due to resource shortages. These kinds of results can help shape a more comprehensive understanding of how different types of vegetation and environmental factors influence conflict.

By leveraging new technologies for data collection, and focusing on specific cases, researchers and development agencies could control the costs of specialized data collection while gathering the information they need to perform robust empirical research that can inform policy design. These tools also provide avenues for policy makers and researchers to fill the data gaps that exist in household level and anthropometric data, addressing key missing data issues at the country level.

5 Conclusions

The question of the linkage between food security and conflict has been widely, but still inconclusively, debated across disciplines for many years, mainly using qualitative or descriptive methods. In the past few years, the increasing availability of more fine-grained and high-quality data, combined with modern econometric analytic approaches, has produced a remarkable wealth of solid quantitative findings. These findings validate, complement and extend descriptive results that causal and substantive linkages exist between food security and violent conflict, spanning the individual, local, regional, country and global levels. Despite the impressive progress that has been made, our paper identifies three fundamental limitations.

First, more and better data on and from conflict zones is required for understanding and monitoring the full diversity, nature and interrelations of food security and violent conflict. At the national level, more reliable and informative data on social, political, economic and institutional variables is required. At the subnational level, the local nature marking many food systems and conflicts needs to be much better accounted for and measured. This particularly includes non-violent aspects of conflict and the political economy of food systems. At the micro level, better information is required on how individuals and groups affect, are affected by and cope with conflict and fragility, including strategies related to food security.

Second, the most robust evidence to date exists on the `reduced-form` links between food security and violent conflict. Achieving a better understanding of the causal transmission mechanisms – including both economic and non-economic channels – that underpin these links is arguably the most important next step for future work. Existing knowledge strongly suggests that food security and violent conflict are coupled through multiple pathways which may a) strongly differ across contexts and b) interact with each other and other factors.

Third, there is a relative dearth of reliable evidence from the analysis of policies and interventions. While designing, implementing and evaluating policies in conflict zones present serious practical and ethical challenges, many subnational interventions related to food security and resilience have been successfully completed. Yet, impacts of improved food security status, and welfare outcome more broadly, on conflict and peace outcomes are often assumed rather than tested rigorously, and systematic learning is rare.

From a policy perspective, results from such approaches are required to produce informed, effective and equitable policies. Preventing the outbreak of violence, supporting individuals and groups' food security during conflict, stimulating post-conflict recovery, reacting to fluctuations in global food prices or injecting food aid, to name a few, are tall tasks in the absence of robust and context-sensitive evidence on the food-security conflict nexus at the national, subnational and micro levels. To illustrate, shifting agriculture to export crops has recently been promoted as "one of the most promising areas of activity in many fragile states" (WEF, 2014). Export crops may create employment, which could reduce conflict by decreasing the incentives of joining an armed group or increasing the state's capacity to provide order and security via increased tax revenues. Yet, export crops also compete with the production of food crops which may affect food security in fragile post-war settings (Bozzoli and Brück 2009) and a rise in global crop prices actually strengthen insurgents and cause an increase in violence in the Philippines (Crost and Felter, 2016). Where, when and how a shift to export crops can reduce conflict thus requires high-quality data and impact analysis, based on institutional insights at the global, national and local levels.

There remains a major push to make food security part of peacebuilding, even though the precise impacts of improved food security on conflict and peace outcomes remain difficult to pin down in the empirical data. The goal of this article is to lend an overarching narrative to the multiple strands of literature dealing with this topic, and tie these to a current challenge facing the policy community. The economics and social science fields have a great deal to offer policy makers working in the food security and conflict nexus, and it is our hope that greater communication between scientists and policy makers can lead to better lives and improved safety for those facing food insecurity and the risk of violence.

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