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Food security and armed conflict: a cross-country analysis

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Food security and armed conflict: a cross-country analysis

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Abstract

Significant progress has been made in improving global food security, yet some countries still face severe challenges. In some cases, violent armed conflict has potentially contributed to local food insecurity due to disruption of food production and agricultural markets. Despite the relevance of this topic in context of tracking global food security, there is a paucity of empirical work examining this cross-country variation. Therefore, this study uses country-level data, covering 106 countries in Africa, Asia, Central and South America between 1961-2011, to estimate the relation between conflict and food security. To proxy food security the dietary energy supply (DES) is used. Results show that conflict is associated with lower food security levels. Specifically conflicts about government power or with large fatality numbers are correlated with a large estimated reduction in the national DES. The results highlight the negative correlation between conflict and food security, illustrating how certain types of conflict could potentially undo years of progress.

Keywords: Food security, armed conflict, cross-section time-series data, error correction model, cross-validation.

JEL codes: O10, O13, O53, O54, O55.

Acknowledgements

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1 Introduction

In the past two decades significant progress has been made in reducing the number of people that face severe levels of food insecurity. A recent report drafted by the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Children's Fund (UNICEF), the World Food Programme (WFP) and the World Health Organization (WHO) on the state of food insecurity and nutrition in the world estimated the number of people that are undernourished at about 815 million in 2016 (FAO, IFAD, UNICEF, WFP and WHO, 2017). A reduction of 185 million compared to a decade before and about 200 million down from the 1991–1992 estimate. These are positive trends, and in general the global food security situation seems to have improved compared to just a few decades ago. Nonetheless, despite important local and regional improvements, progress has been an uneven process with some countries still facing severe difficulties in managing the food supply appropriately for their population. The 2007–2008 global food price crisis was a stark reminder of some of the difficulties remaining as it put a number of developing countries under severe stress (Verpoorten *et al.*, 2013). Compared to the global trend progress has been slower in Southern Africa as well as East Asia. In some regions setbacks have been linked to political instability such as the Arab countries (Maystadt, Trinh Tan and Breisinger, 2014), while it is likely that other conflict and post-conflict countries face similar hindrances (Messer and Cohen, 2015). Indeed, the 2017 report on food insecurity and nutrition in the world by the FAO, IFAD, UNICEF, WFP and WHO found that after a long declining trend in the number of people that are undernourished, the estimated recent increase was observed most notably in areas affected by conflict (FAO, IFAD, UNICEF, WFP and WHO, 2017).

There is a complex relation between food security and violent armed conflict, as conflict can affect food security via various channels (see Martin-Shields and Stojetz [2017] for a complete overview), and food security itself has been identified as a conflict determinant (Pinstrup-Andersen and Shimokawa, 2008). Conflict potentially reduces food availability and access as the fighting might disrupt agricultural production and markets. During the course of a conflict food systems are often damaged, this includes direct damage such as the destruction of crops or arable land, but also labour diversion away from the agricultural sector, and in some cases entails a reduction in capital investments (Teodosijević, 2003). Although most conflicts tend to be highly localised (Buhaug and Gleditsch, 2008), there are potentially adverse effects at the national level due to the disruptive effects on the agricultural sector. For example, Teodosijević (2003) showed that during conflict-years production levels dropped, bearing negative consequences for food supply levels. In a sample of 38 countries that experienced conflict between 1961–2000, Teodosijević (2003) found a 7 percent decrease in daily energy supply. These results are echoed by Hitzhusen and Jeanty (2006) using data for 76 countries between 1970–2002 and in similar vein Gates *et al.* (2012) estimated that a medium-sized conflict increased undernourishment by 3.3 percent.

Despite the relevance of this particular topic, specifically in context of tracking global food security, there are relatively few empirical studies at the macro-level. This study therefore contributes to a small literature by estimating the correlation between the incidence of violent armed conflict and food supply levels, measured by the dietary energy supply (DES). The macro analysis presented uses data aggregated at the country-level, covering 106 countries in Africa, Asia, Central and South America for the period 1961–2011. In contrast with existing work, this study covers a larger sample in terms of countries and years, and examines the effects focusing on different types of conflict. Although this study adds to a relatively small literature, its contribution is important as it helps illustrate how the incidence of violent armed conflict can lead to a reversal in the progress made and add to the number of people that face hunger (FAO, IFAD, UNICEF, WFP and WHO, 2017).

The analysis shows that conflict is indeed associated with decreases in food supply levels. Conflicts with higher intensity levels, in terms of battle-related fatalities, and conflicts that involve issues about government power tend to be more disruptive as illustrated by a larger estimated reduction in the average dietary energy supply. In contrast, conflicts where territory is the main incompatibility seemingly have little to no effect on the average dietary energy supply at the country level. Although the regression analysis shows that on average there is a negative effect, the exploratory data analysis shows that there are possibly diverging effects across countries, the result of the type of conflict. With regard to the results, it is important to note that although using country-level data can help provide insights into macro-level trends, a shortcoming of this approach is that some information is lost due to the level of aggregation. Using the country-year as unit of analysis means that certain sub-national effects might not be properly accounted for, such as local variation in DES and conflict.[1] Nonetheless, the results of this study still provide useful information on the country-level dynamics between armed conflict and food security, highlighting the negative correlation and illustrating how certain types of conflict could potentially undo years of progress.

1 For an example using micro-level data see the study by Brück, d'Errico and Pietrelli (2018).

2 Data

2.1 Dietary energy supply

Measuring food security can be challenging given the myriad factors that influence the supply and demand of food, and which eventually contribute to determining whether an individual has sufficient access to food that will meet the dietary needs. At a macro level it is almost impossible to measure for each household or individual the amount of food a person consumes, which entails that a suitable alternative measure or proxy is required. Therefore, this study will rely on an aggregate measure that captures the available dietary energy supply (DES) in terms of kilocalories per day per capita (kcal/day/capita). The DES is a main indicator of food security used in the literature (Cafiero, 2013; Pangaribowo, Gerber and Torero, 2013). This measure is calculated by taking the total supply of food in a country available for domestic consumption divided by the population size to arrive at a per capita measure. The supply of food available for domestic consumption itself is calculated by adding food imports to the national food production and subtracting any food exports, as well as accounting for changes in available stocks. Due to its construction this measure accounts for various channels that influence food supply in a country and thus affects food security.[2]

In contrast, one could use other proxy variables such as the infant mortality rate for instance (Magrini *et al.*, 2015). However, this would entail that the effect of violent armed conflict on food security is estimated indirectly through food utilisation rather than through the available supply. Moreover, there are additional concerns with regard to the measurement error in this type of data (Jerven, 2011, 2016). There are other possible food security indicators such as the prevalence of undernourishment or food deficit depth, however these are subject to limited data availability.

Data on DES is taken from the FAO Food Balance Sheets (FAO, 2016) which is the most comprehensive global dataset available for this type of data. The coverage is relatively good: the sample includes data for 106 countries in Africa, Asia, and Central and South America covering the period 1961–2011.[3] Although the data source provides a comprehensive global dataset, there are some shortcomings concerning the quality since the given information are all derived statistics, where the input data comes from a variety of sources which could introduce some measurement error.

At a conceptual level, the largest shortcoming of the data is the fact that subsistence farming, which is an important source of food supply in developing countries, is not accounted for due to data collection challenges. Since the rural poor often depend on this type of agricultural activity for their food supply, it is likely that the country average, as provided by the data, will overestimate the DES for the rural population. Additionally, using a country average also entails that issues such as access or inequality are omitted as the aggregated data does not account for within-country variation. Taking these shortcomings into consideration, this entails that using this data will only result in a statistical analysis of broad patterns across countries. The empirical

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2 As an example, armed conflict in a rural area likely reduces food production due to the destruction of crops as well as diversion of labour away from the productive agricultural sector. This production loss could be compensated by increased food imports which would hamper the negative effect on food supply. Similarly, a bad harvest due to extreme weather events on one year could be compensated by available stocks.

3 Some countries are missing, such as the Democratic Republic of the Congo and Somalia, likely the result of data collection issues. Similarly, data is available for 2012 and 2013 but significantly fewer countries are included.

results should therefore be interpreted with some caution given the discussed limitations of the data. Nonetheless, despite some shortcomings, the data does provide a reasonable approximation of a country's food security situation (de Haen, Klasen and Qaim, 2011; Wheeler and von Braun, 2013; Blaydes and Kayser, 2011).

2.2 Violent armed conflict

Data on violent armed conflict is taken from the Armed Conflict Dataset (version 4, 2016) of the Uppsala Conflict Data Program (UCDP)/Peace Research Institute Oslo (PRIO) which has a global coverage including conflicts for the period 1946–2015 (Gleditsch *et al.*, 2002). Violent armed conflict is in this case defined as a contested incompatibility concerning government and/or territory between two parties, one of which is the government, and where armed force has lead to at least 25 battle-related deaths. Because of this definition of conflict, very small incidents of violence with fatality numbers below the 25 fatality thresholds will not be included in the dataset, nor does it include types of violence where the state is not involved such as clashes between ethnic groups or farmer-herder violence. Due to its salience, this study will focus on intrastate or civil conflicts. These are cases where armed force is used between the government and insurgency groups. To capture conflict incidence a dummy variable is coded for each country-year, taking value 1 if there was a conflict and 0 otherwise. In addition, a dummy variable for civil wars is used, which are conflicts with a fatality threshold of at least 1 000 battle related deaths.[4] To reiterate conflict refers to all cases of armed force where there are at least 25 battle-related deaths, and wars where there are a 1 000 battle related deaths.

Civil wars will likely have a larger negative effect on food supply level due to their scale of disruption, given that by definition wars are large in number of fatalities. Besides exploiting the level of conflict intensity, we can also consider the incompatibility of the conflict and how this is related to food supply levels. The UCDP/PRIO data contains information about whether the conflict is about government control or territory. In this case, we would expect that conflicts about territory possibly have smaller adverse effects since they are more localised and possibly less disruptive to the national food security situation.

[4] Due to data quality additional levels for the fatality numbers (Lacina and Gleditsch, 2005) cannot be exploited and therefore the literature standard are used.

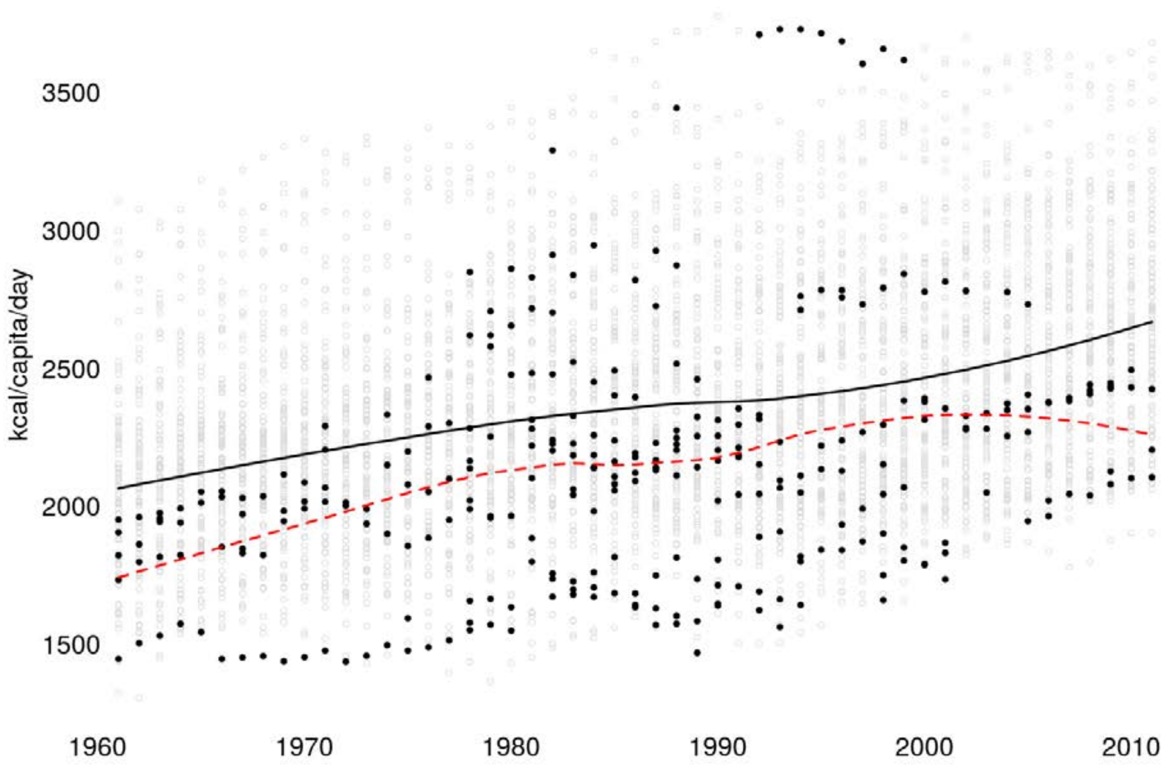
3 Exploratory data analysis

The analysis begins using data visualisation to examine whether there is some descriptive evidence for the effect of conflict on food supply, before it turns to a more formal statistical analysis. Figure 1 presents a raw data plot of the DES data where the solid black points indicate country-years with a civil war. Two locally fitted trend lines are added to the plot to indicate the trend over time. The solid black line fits the trend for all observations and illustrates that there has been a gradual increase in DES level over the years. Comparing the average DES level during the 1960s with the period since 2006 shows that there has been an increase of 488 kcal per day per capita. The red dashed line is the locally fitted trend line for the country-years with civil war (conflicts with more than 1000 battle-related fatalities in a year) and shows that over time there has been a gradual increase in DES levels too, but the average levels are lower and there is actually a downward trend in the last decade.

Countries that have experienced long sustained conflicts of 10 years or more between 1961–2000, report slightly lower average DES values; 2240 ($\sigma = 405$) compared to 2367 ($\sigma = 301$) for countries without conflict. In general, though most countries have experienced an upward trend in DES levels, although average levels are slightly lower for countries having experienced conflict, indicating that they are lagging behind the global trend.

The figure also illustrates that a number of countries that experienced civil war have relatively high levels of food supply. Countries in this particular subset include reasonably well-developed economies such as Colombia, Israel, South Africa and Turkey. In general, though countries with a war past, such as Cambodia, Yemen and Angola, are found below the annual trend line. Nonetheless, there are also some countries that have very low DES levels which did not experience much conflict such as Benin and Bolivia.

Figure 1 Dietary energy supply levels over time



Note: The black dots indicate country-years with civil wars (battle-related fatalities > 1 000); the black line is a locally weighted trend line for all observations; red dashed line is a locally weighted line for the country-years experiencing civil war.

Source: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2016.

The data is split into individual time-series to examine the trend per country, some examples of which are given in Figure 2 and 3. Figure 2 displays a number of countries that have experienced conflict, political instability, or other socio-economic problems.

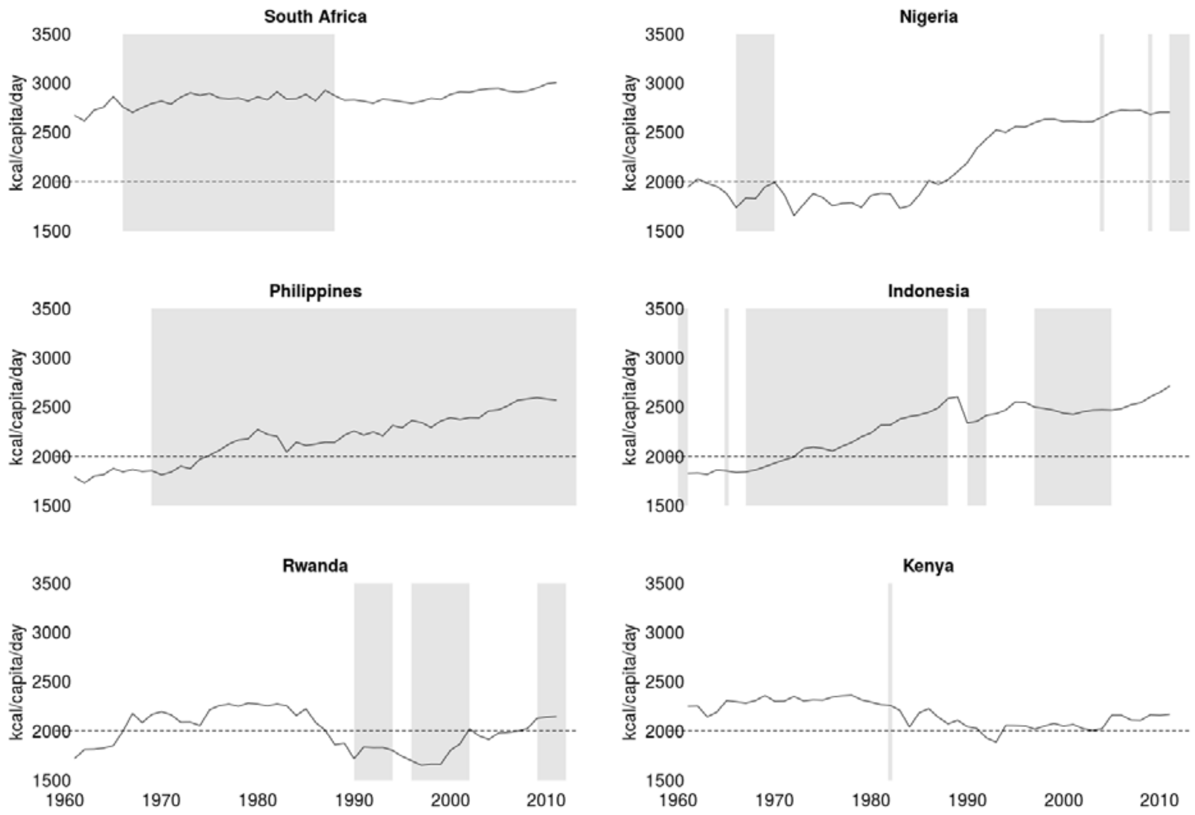
The upper panel of the figure shows the two largest economies on the African continent: South Africa and Nigeria. South Africa has a reasonably well-developed economy, even after years of international embargoes during Apartheid. The data shows levels comparable to that of developed countries in Europe and the DES has remained remarkably constant over time; only showing a slight decrease during the 1990s. It is once more important to stress here that the data shows the country average; in practice, the situation on the ground in a rural area in Polokwane will likely be very different from that in Cape Town.

In contrast to South Africa, in Nigeria the average dietary energy supply remained beneath 2 000 kcal a day, used as a benchmark here, for a long period of time. There are large fluctuations in the data throughout the 1960s and 1970s, and it is only since the 1990s that there has been an upward trend converging to the global average. This increase in food supply levels could be linked to oil revenues. Despite its agricultural potential, Nigeria depends on imports for large parts of its food supply and over the years the government has used oil revenues to keep domestic food prices low. In 2012 fuel subsidies were removed, which led amongst others to increases in food prices due to higher transport costs. Following the removal of the fuel subsidies there were nationwide protests and the army had to be deployed to contain the situation (The Economist, 2012).

The middle panel focuses on two large South-East Asian economies, the Philippines and Indonesia, two countries that both have been harried by different low-intensity conflicts over the years. These conflicts include the struggle for an autonomous state in the Mindanao in the Philippines and Timor Leste (now independent) in Indonesia. Similar to other South Asian countries, they have both experienced positive economic growth rates over the years as a result of export-oriented policies geared mainly towards raw materials. For the Philippines there is an initial increase in food supply which is followed by a rather large lull during the 1980s, a period that saw increased violence from the communist insurgency active mainly in the rural areas. The progress in Indonesia was cut short at the end of the 1980s, coinciding with the recession in the economy. A more gradual decrease in DES levels occurred in the late 1990s and lasted until about 2003. The 1998 recession caused large increases in food prices leading to riots which eventually culminated in the end of the 30-year reign of Suharto. A parallel with the 2010–2011 Arab Spring, which panned out under similar circumstance, can be made here. Following Suharto's resignation in 1998 violence continued, albeit at low intensities until 2003.

The bottom of the panel shows the data for Rwanda and Kenya, two countries in East Africa. Rwanda, a small land-locked country, has not experienced much progress in improving food supply levels in the past decades, bucking the global trend. After gaining independence there was some improvement which fizzled out relatively quickly before going into a long decline, before the start of the civil war in 1990. A further decrease followed during and after the 1994 genocide, an event that has been linked to issues of land access (Verwimp, 2005). Only since the end of the Second Congo War, in which the country was involved, food supply levels have been increasing, reaching levels similar to those in the 1980s. In contrast, Kenya has been a relatively stable country except for almost endemic low-intensity violence between pastoralists in the North-Western parts of the country. However, it has suffered the severe consequences from the 1980s AIDS epidemic. Over the years food supply levels have not deviated much from the benchmark level, such that they have not followed the global trend.

Figure 2 Time series data for dietary energy supply for selected individual countries



Note: The grey shaded areas indicate periods with violent armed conflict.

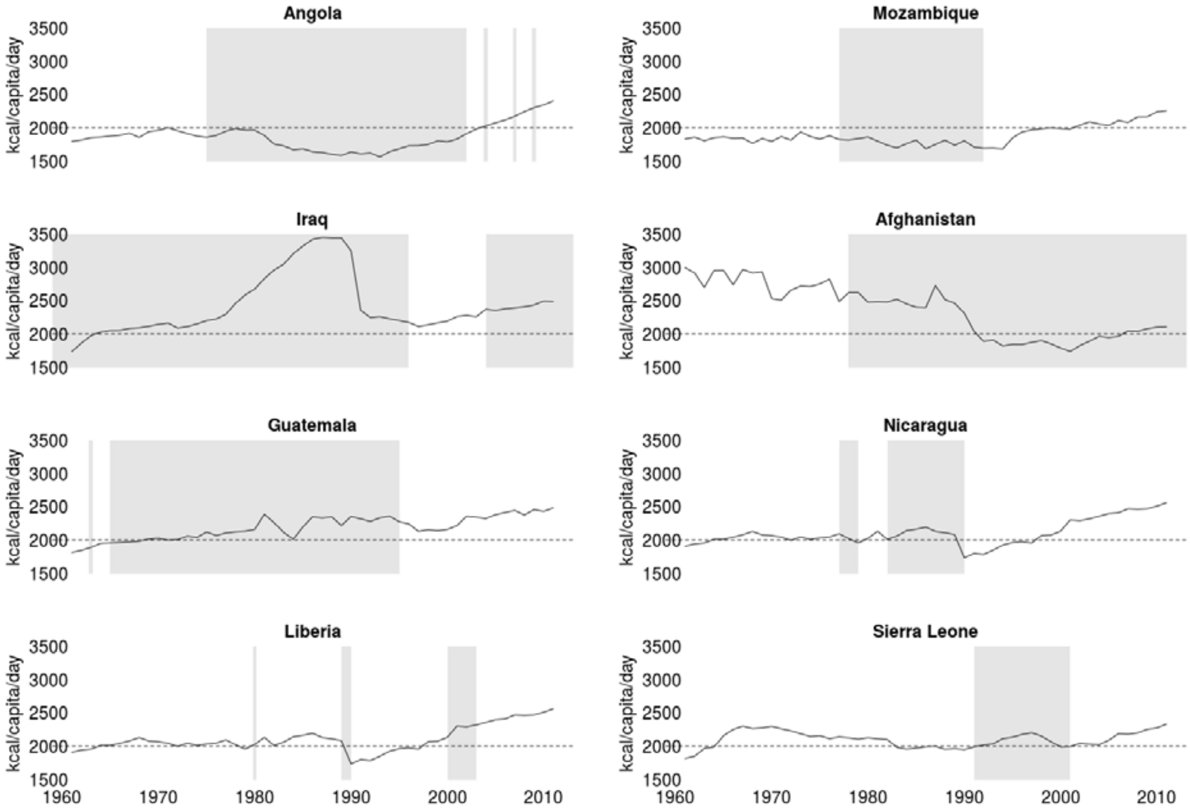
Source: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2016.

These individual cases provide some descriptive evidence of how conflict or instability could affect food supply levels in a country. It illustrates that there are diverging effects and that not all countries necessarily experience declines following episodes of violence. Note however that in this selection of examples all countries, except Rwanda, experienced conflict with relatively minor violence levels and often involved localised conflicts, meaning that not the entire country is necessarily affected. In contrast, Figure 3 shows the data for an additional selection of countries which experienced more severe types of violent armed conflict, often affecting larger parts of the country.

Angola and Mozambique (upper panel) are two former Portuguese colonies which both fought long independence wars followed by post-colonial civil wars. In Angola the independence war lasted 13 years from 1961 to 1974, which was followed by a civil war that lasted until 2002. Similarly, an independence war erupted in Mozambique in 1964 which lasted until 1974 when a cease fire was reached. Fighting resumed shortly after the 1975 negotiated independence from Portugal culminating into a civil war that lasted until 1992. Both countries exhibit DES levels consistently below the benchmark level of 2 000 kilo calories per capita per day. The figure also shows that for both countries food security levels have started to increase, since the 1990s in Mozambique after the civil war, and also during the 1990s in the later phases of the war in Angola. However, food producing areas are still affected by the conflict due to the presence of land mines which makes certain agricultural activities dangerous (Andersson, da

Sousa and Paredes, 1995; Unruh, Heynen and Hossler, 2003). One caveat in the analysis here is that due to the importance of subsistence agriculture in these countries the data might not be as reliable as in other cases.

Figure 3 Time series data for dietary energy supply for selected individual countries



Note: The grey shaded areas indicate periods with violent armed conflict.

Source: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2016.

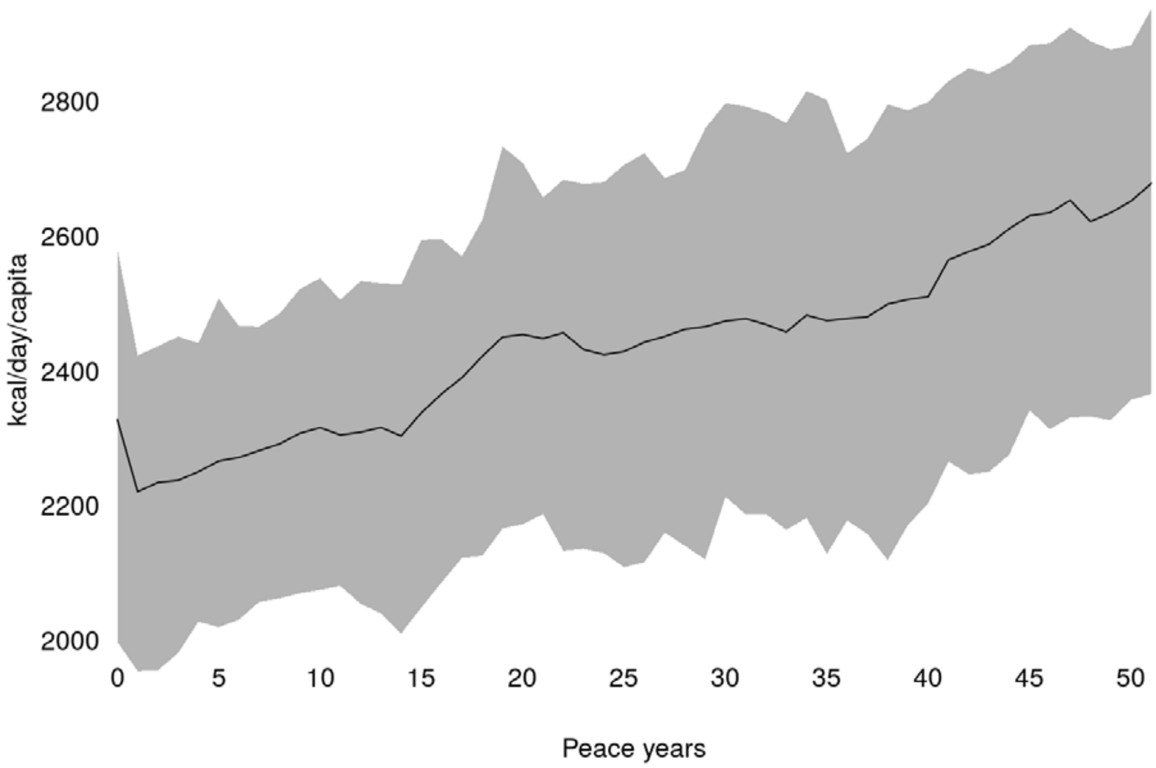
The second panel from the top shows Iraq and Afghanistan, two countries that have been subject to foreign involvement in the past decade. Like many Arab countries food supply levels in Iraq followed a global upward trend, until a large decrease was witnessed around the time of the First Gulf War. At this point it is not clear how much of an actual decrease there actually is due to problems with measuring food supply in a country engaged in such an internationalised war such as the Gulf War. Nonetheless, improvements in food supply have been very slow ever since the Gulf War erupted. Afghanistan has experienced a lot of volatility concerning food security. The large decrease in food supply levels coincides with the end of the Soviet occupation in 1988, with a further decline under Taliban rule. Only since the forceful removal of the Taliban with the assistance of international forces has the food situation started to improve, although regional differences exist (Souza and Jolliffe, 2013).

The development of food supply levels in Guatemala and Nicaragua have been very similar to those in Angola and Mozambique. Both Central American countries have experienced prolonged periods of conflict, especially Guatemala where the civil war lasted for more than 30 years. For Guatemala we can observe that the situation around 2010 is only slightly better compared to that during the final stages of the civil war in the early 1990s. Indeed, after the peace treaty of 1996 there was a sharp decline in food supply in the years immediately following. Around 2010 Guatemala was relatively food insecure, especially in the rural areas, with supply levels comparable to that of Iraq and Sri Lanka. Food supply levels in Nicaragua have followed a similar trend to those of Guatemala with a very sharp decrease at the end of the civil war, but things have been improving since. The average food supply level between 2009–2011 was about 88 percent of that of neighbouring Costa Rica which did not experience any civil war.

The lower panel shows the time-series for Liberia and Sierra Leone, two West African countries which experienced intense civil war through the 1990s. Both countries had moderate levels of food security to being with. Liberia seems to have had a slightly better balance but experienced rapid declines at the start of the civil war in 1989. There is a slight improvement in the situation between 1997 and 1999, when the war continues. Sierra Leone already experienced a long slump in the development of food security prior to the civil war between 1991–2002.

Having analysed these critical trends, the analysis of aggregate trends is developed by examining the relation between the duration of peace spells and the associated levels of food supply. In this context a peace spell is simply the duration of subsequent years without a recorded conflict according to the armed conflict dataset. Exploiting the time-series variation in the data, for each unique duration length, the data is aggregated to arrive at an average level of food supply. Figure 4 shows the results where the solid line indicates the average and the grey shaded area the 50 percent uncertainty interval. The average food supply level for zero peace years starts out relatively high which is due to the inclusion of countries like Turkey and Israel which are both coded as countries experiencing conflict for the whole period but have relatively well-developed economies and high food supply levels, pushing the average upwards. The figure further illustrates that longer peace duration is associated with higher food supply levels, likely the result of the fact that the upward annual trend is not interrupted. This is a very gradual process where on average each extra year of peace is associated with about a 9 kcal increase in the daily per capita dietary energy supply. Moving from one year of peace to two corresponds to an average increase of 13 kcal/day/capita, moving from 5 to 10 corresponds to a 49 kcal/day/capita increase, and going from 10 to 20 with an increase of 138 kcal/day/capita.

Figure 4 Link between duration of peace (absence of violent armed conflict) and dietary energy supply levels



Note: The black line indicates the average for peace duration and the grey-shaded are indicates the 50 percent uncertainty interval.

Source: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2016.

4 Empirical framework

A regression model is fitted to the data to estimate the effect of conflict on food supply levels, as measured by the DES, where the country-year is used as unit of analysis. This means that the results provide an insight about the correlation between conflict and food supply at the macro level, but this comes at the cost of losing subnational variation. Similar to the study by Blaydes and Kayser (2011), an Error Correction Model (ECM) is used to fit the data, with the following functional form for the variation in food supply as proxied by calorie intake:

$$\Delta Calorie\ Intake_t = \alpha 0 + \alpha 1 Calorie\ Intake_{t-1} + \beta 0 \Delta Conflict_t + \beta 1 Conflict_{t-1} \quad \textbf{(1)}$$

This estimation framework links changes in food supply to i) its lagged value, ii) change in conflict status (as defined below), and iii) the lagged value of the conflict indicator. The ECM is used since the data for the outcome variable exhibits, at least on average, and upward trend over time, as shown in the exploratory data analysis.[5] The model estimates the impact of conflict on dietary energy supply as deviations from the long-run equilibrium, it therefore separates the short-run dynamics from the long-run relationship. These short-term effects of changes in the explanatory variables are captured by the model where parameter α1 is an estimate of the error correction mechanism (i.e., the rate at which relationship returns to the equilibrium). The main model specification estimates the effect of changes in conflict status conditional on past food security levels and conflict incidence.

Estimating the model there are two potential econometric issues, namely i) unobserved heterogeneity and ii) endogeneity.

Concerning unobserved heterogeneity, either arising from cross-country differences or temporal dynamics, different model specifications are used including country indicators and time trend, which will be discussed below.

Endogeneity is a harder problem to tackle due to the dynamic and complex relationship between food security and conflict, where food security is possibly a determinant of conflict (Pinstrup-Andersen and Shimokawa, 2008). Although the ECM separates the short-term shocks of conflict on food security from its long-term trend, it does not account fully for the problem of reverse causality. As such, the results can only be interpreted as correlations, so we will refrain from making any statements about causality.[6] Nonetheless, the results still provide useful information on the relation between food security and conflict. The model is fitted using Bayesian regression methods, which entails that the parameters are considered to be random and estimated using conditional probability.[7] The main advantage of this approach is that the estimated parameters have an intuitive probabilistic interpretation. Therefore, the uncertainty intervals provide a

[5] Note that contrary to popular perception the variables included in an ECD model actually do not have to be co-integrated (de Boef and Keele, 2008).

[6] In general, establishing causality is difficult given the nature of the data (Jerven, 2016).

[7] The coefficients and their uncertainty interval are derived from the posterior density which is constructed using a Gibbs sampler (Plummer, 2003) which is a Markov Chain Monte Carlo (MCMC) algorithm. Three MCMC chains are run in parallel, each with 2000 iterations, the first 500 of which are discarded as burn-in to guarantee that the estimates are taken from the posterior distribution (Brooks and Gelman, 1998; Brooks *et al.*, 2011). In this case the coefficients and their uncertainty intervals are derived as averages across the remaining iterations. The parameters in the model are modelled using vague or non-informative prior distribution (N [0, 10]) (Gelman *et al.*, 1995). As a result of using a non-informative prior distribution the estimated coefficients will be similar to maximum likelihood estimation.

probability distribution of the parameter, which gives more information on the uncertainty of the direction and magnitude of the estimates.[8]

Given the coding of the dummy variables $Conflict_t$ and $Conflict_{t-1}$, the model accounts for four different conflict situations: i) the absence of conflict when both $Conflict_t$ and $Conflict_{t-1}$ are 0, ii) conflict onset when $Conflict_t = 1$ and $Conflict_{t-1} = 0$, iii) ongoing conflicts or conflict incidence when both $Conflict_t$ and $Conflict_{t-1}$ equal 1, and finally iv) conflict off set when $Conflict_t = 0$ and $Conflict_{t-1} = 1$.

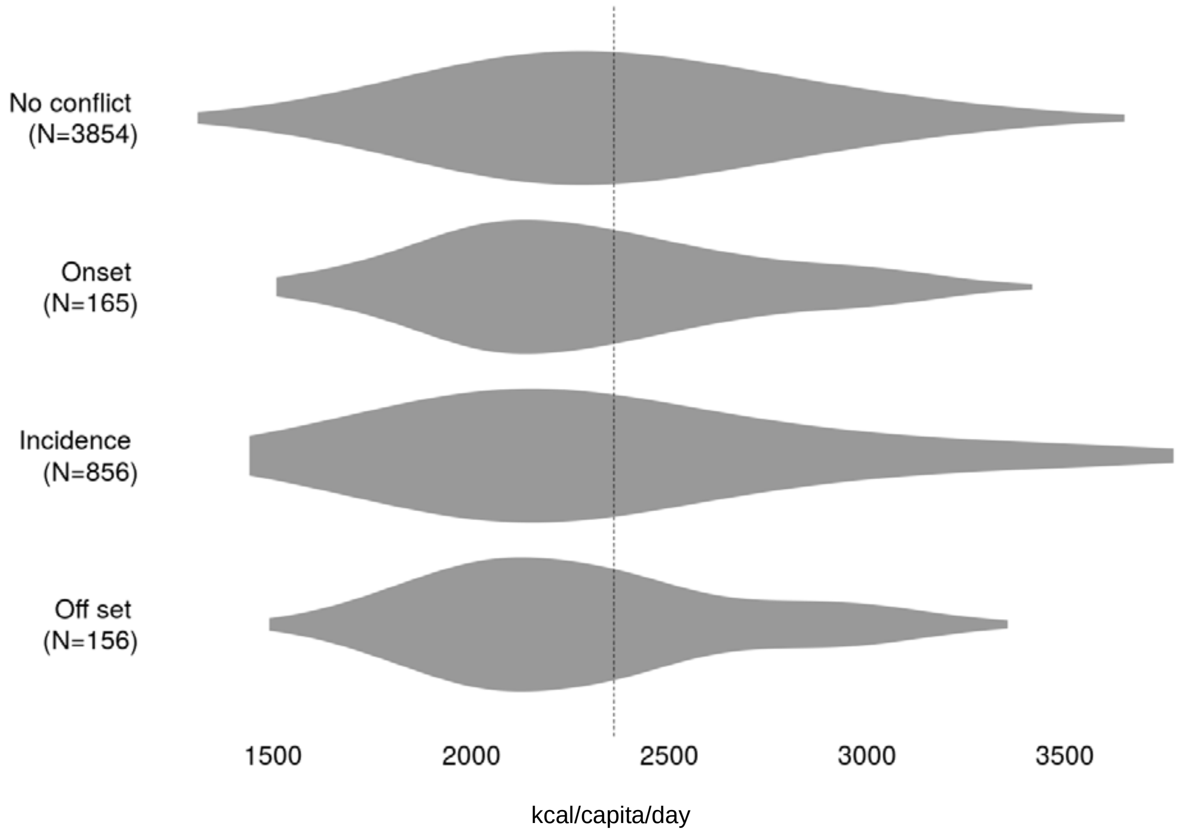
As figure 5 shows, there are some differences in food supply levels where country-years with conflict onset or incidence have lower levels compared to peaceful years (dotted line indicates sample average). At the aggregate level these differences are small though as the figure illustrates. Table 1 provides additional summary statistics for the main variables.

Table 1 Summary statistics for 106 countries in Africa, Asia, and Central and South America, 1962–2011 (N = 5001)

Variable	Mean	Standard deviation	Min	Max
∆ Calorie intake	12.30	72.79	-893	628
Calorie intaket−1	2348	423.37	1308	3775
∆ Conflict	0.002	0.25	-1	1
Conflictt−1	0.20	0.40	0	1
∆ War	-0.001	0.19	-1	1
Wart−1	0.06	0.24	0	1

[8] This in contrast with a Frequentist uncertainty interval which just gives a range of outcomes.

Figure 5 Distribution of dietary energy supply levels conditional on conflict status



Note: The vertical black line indicates the average for the whole sample (N = 5001).

Source: FAO Food Balance Sheets, UCDP/PRIO Armed Conflict Dataset v4-2016.

5 Regression analysis

Table 2 reports the mean estimated effect; the 95 percent uncertainty interval is given in parentheses. As a measure for the fit of the model the Root Mean Squared Error (RMSE) is included where model performance is better for smaller errors. The results show that the different model specifications have very similar error rates, all close in size to the standard deviation of the outcome variable. Column 1 shows the main model specification as shown in Equation 1, where the change in calorie intake is regressed on the temporal lag of calorie intake, change in conflict status, and the conflict incidence indicator. In this case the model includes all types of conflict at the 25 battle-related fatality threshold as defined by UCDP/PRIO. The results indicate that conflict onset is associated with a drop in food supply levels of 8 kcal/day/capita on average in year t and an additional 5 kcal/day/capita the year after. For both the change in conflict status and the lagged conflict indicator, the coefficient has a negative sign with a probability of 0.95. The estimated effect of the lagged value of food supply levels is very small at −0.01.[9]

To test the robustness of the results a number of adjustments are made to the model specification. To account for a common trend over time across countries, a linear year trend is added (col.2), showing a positive estimated effect but with a very small magnitude. To account for country characteristics such as income level (proxied by GDP) and regime type (as defined below), a multilevel model is used to estimate their effect. In the multilevel model these two variables are modelled on the constant, creating a country-specific intercept, by using their average value as is done in (Danneman and Ritter, 2014).[10]

[9] Following de Boef and Keele (2008); Blaydes and Kayser (2011) we can use this coefficient to calculate the long run effect using $\frac{\beta 0+\beta 1}{1-\alpha 1}$ which in the case of the model in column 1 shows a further decrease of 13 kcal/capita/day. This long run effect will occur each year at progressive smaller magnitudes dictated by the error correction rate, until the effect peters out.

[10] Note that is approach is similar to including country indicators, or country fixed effects. However, the main advantage of this approach is that in contrast with a fixed effects specification the between-variation is not removed but can be modelled following the method described in Bell and Jones (2015).

Table 2 Predicting change in calorie intake in country *j*, 1962–2011

Specification	Conflict (1)	Conflict (2)	Conflict (3)	War (4)	Government conflict (5)	Territorial conflict (6)
Calorie intake$_{t-1}$	-0.012 (-0.017;-0.007)	-0.015 (-0.020;-0.010)	-0.039 (-0.046;-0.031)	-0.013 (-0.017;-0.008)	-0.013 (-0.017;-0.008)	-0.012 (-0.016;-0.007)
Δ Conflict	-8 (-16;1)	-8 (-16;1)	-8 (-17;0)	-25 (-36;-13)	-13 (-22;-4)	-2 (-15;12)
Conflict $_{t-1}$	-5 (-10;1)	-5 (-11;0)	-6 (-13;1)	-19 (-28;-9)	-11 (-17;-5)	5 (-2;12)
Year		0.24 (0.09;0.39)				
GDP$_{unit}$			8 (-7;24)			
Regime$_{unit}$			11 (-2;22)			
Intercept	41 (30;53)	42 (30;52)	73 (42;105)	43 (33;55)	44 (32;55)	40 (29;52)
RMSE	72.57	72.49	71.37	72.42	72.48	72.58
Conflict-years	1005	1005	1005	295	678	457

Notes: N = 5001. Conflict-years are the number of observations coded as conflict in the data. Table presents the average of the posterior distribution along with the 95 percent uncertainty interval between parentheses. Estimates are taken as the mean from 3 parallel chains with 2 000 iterations each where the first 500 are discarded as burn-in, with a thinning rate set to 5. Priors are N (0, 10).

There are two reasons why the annual variation in income and regime type is not exploited. First, both are slow moving meaning that there is actually very little variation over time per country. Moreover, concerning the GDP data annual estimates likely exhibit measurement error for many developing countries (Heston, 1994; Johnson *et al.*, 2009; Jerven, 2011, 2016). Second, including the annual variation of GDP and regime type could lead to a bad control issue (Angrist and Pischke, 2008), where the introduced covariates could also be an outcome variable. Given that conflict is correlated with both income and regime type, this alternative approach is therefore taken.

Income is measured by GDP per capita in USD 10 000, with data taken from the World Development Indicators. Regime type is measured on a 1–5 scale, following Goldstone *et al.* (2010), where higher values correspond to more democratic regimes.[11] The estimation shows (col.3) that the main results are robust both in terms of the direction and magnitude of the effect. Interestingly, including the additional control does not lead to a very large decrease in the error. The results also show that higher income countries and more democratic regimes are positively associated with DES, echoing the results by Blaydes and Kayser (2011).

The data from the armed conflict dataset contains information on the intensity of the conflict, making a distinction between conflicts and war, and the incompatibility of the conflict which we can exploit in the analysis. First we examine the effect of civil wars on changes in DES levels, as conflicts with higher intensity levels might have a larger impact on the food supply levels due

[11] GDP per capita is on average USD 4 496 (standard deviation equals USD 9 129), while regime type has an average of 2.4 (standard deviation of 0.9).

to scale of their destruction. The estimates (col.4) indeed hint at a larger effect as there is about a threefold increase in the magnitude associated with the change of the conflict indicator, and an almost fourfold increase for the estimated effect of the conflict lag. The uncertainty associated with the estimates is also lower; both show a 100 percent chance of a negative effect. There is also an increase in the estimated effect for violent armed conflict about government power (col.5), although the increase here is not so severe as in the case of civil wars.

As discussed in the data section, we would expect to see a larger negative effect associated with civil wars as the geographic spread of this type of conflict is likely to be larger. In addition, this type of armed conflict will also place a heavier burden on the government in their effort to counter these insurgencies compared to more localised conflicts which are arguably easier to contain. Indeed, the estimate for conflict concerning territorial incompatibilities, as coded by UCDP, seems to have a much smaller effect and the direction is negative with a probability of just 0.64 based on the posterior distribution. Since territorial conflicts are often highly localised, the effect of this type of violence on the national average of food consumption might be relatively small.

The main estimation results use an outcome variable which is coded capturing the change in conflict status distinguishing between three stage in the conflict process, namely i) onset, ii) incidence, and iii) offset. Since going in and out of conflict might be different processes, to test the effect of this assumption on the estimation, the model is re-estimated dropping the coding for conflict offset, the results for which are reported in table 3.[12]

Recoding the variable capturing conflict status does not alter the results much in terms of the direction of the effect, but there are some slight changes in the estimated magnitudes.[13] Most noticeably, there seems to be some convergence in the magnitude of the effect between the model including all types of civil conflict and the models for civil wars and conflict concerning government power. For instance, the estimated effect for all conflict types has increased, moving from -8 to -10, whereas the estimated effect for civil wars has been reduced, dropping from -25 to -15. The results also show that the uncertainty interval has become smaller considerably. The coefficient for the model estimating the effect of conflict about government power also shows a decrease going from -13 to -10. For territorial conflicts the estimate for the variable capturing conflict onset increased but the effect of the variable capturing lagged conflict incidence almost stays the same. Importantly, even in the case of a conflict about territory the estimated effect is negative with a relatively high probability of 0.75.[14]

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[12] I.e. instead of -1 these observations get a value of 0.

[13] I also carry out a robustness check using the length of peace years in the model specification, but the estimate is near zero.

[14] This probability is 0.96 for conflicts about government power.

Table 3 Estimated coefficients for recoded conflict indicator

Specifications	∆ Conflict	Conflict$_{t\ 1}$
All civil conflicts	-10 (-21; 1)	-3 (-8; 2)
Civil wars	-16 (-25; -5)	-4 (-8; 2)
Government conflicts	-11 (-22; 1)	-9 (-15; -3)
Territorial conflicts	-6 (-24; 11)	5 (-1; 12)

Notes: N = 5001. Table presents the average of the posterior distribution along with the 95 percent uncertainty interval between parentheses. Estimates are taken as the mean from 3 parallel chains with 2 000 iterations each where the first 500 are discarded as burn-in, with a thinning rate set to 5. Priors are N (0, 10).

6 Conclusions

This study examined the link between food security and violent armed conflict using data aggregated at the country level for 106 countries in the global South (Africa, Asia, and Central and South America) between 1961–2011. The exploratory data analysis illustrated that although there is global progress in improving the levels of food supply, conflict affected countries likely experience slower progress. Additionally, there are potentially diverging effects of conflict on food security, where the data showed that while some countries experience large setbacks, others do not seem to be affected at all, at least not at an aggregate level.

One possible explanation for the diverging effects is the type of conflict occurring in a country as the regression analysis examined more closely. Using information on the intensity and incompatibility of the conflict, the results indicated that civil wars and violent armed conflict about government power tend to show larger negative correlations with changes in food security levels compared to for instance territorial conflicts. It is important to note however that a convergence in the estimated magnitude of the correlation occurs once we code the conflict variable to differentiate between peace and conflict offset, which were conflated in the original coding scheme.

Nonetheless, the regression analysis robustly showed that violent armed conflict is negatively associated with food security levels both in the short and long run. The magnitude of this estimated effect was not large compared to the normal variation in the data, but here we also need to take into account that it might possibly be an underestimate given the fact that the data used to proxy for food security does not take into account subsistence agriculture. This type of agricultural activity is still important for many people in developing countries included in the sample, and they are likely to be affected given the rural character of most conflicts (Kalyvas, 2004).

The main aim of this study was to examine macro-level trends concerning the food security-conflict nexus across countries, which means that this study relied on the use of data aggregated at the country level. Although this approach provides advantages in studying global trends, the use of aggregated data does come at the cost of losing within-country variation, both in terms of food security and conflict. As such, local conflict dynamics are only partially accounted for, while inequality regarding access to food is omitted from the analysis due to data availability. To analyse these dynamics, a micro-level approach could be advantageous, illustrated for instance by the work of Souza and Jolliffe (2013), Brück, d'Errico and Pietrelli (2018), and Mercier *et al.* (2017) or some other examples listed in Martin-Shields and Stojetz (2017). Nonetheless, the study presented here is complementary to these micro-level type studies and provides a bigger picture of the linkages between conflict and food security at a global scale.

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