Analyzing the Effects of Conflicts on Food Security in Developing Countries:

An Instrumental Variable Panel Data Approach

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Abstract: This study applies instrumental variable panel data techniques to estimate the effects of civil wars and conflicts on food security in developing countries. From a statistical standpoint, the results glaringly pinpoint the danger of using conventional panel data estimators when endogeneity is of conventional type, i.e. with respect to the idiosyncratic error term. However, from a policy perspective, we find that, in general, civil wars and conflicts are detrimental to food security, but the negative effects are more severe for countries unable to make available for their citizens the minimum dietary energy requirement under which a country is qualified for food aid.

Key words: Unbalanced Panel data, Error Component two-stage least squares, Instrumental variable, civil war, food security

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Introduction

Food insecurity and armed conflicts are two major problems that have aroused the attention of international institutions, political analysts, and governments in developing countries. Over several decades, resources have been mobilized to reduce the number of hungry in the world, particularly in developing countries. The 1996 World Food Summit set the ambitious goal of halving to 400 million the number of hungry in the world by the year 2015. In addition, the first of the eight millennium development goals set at the 2000 Millennium Summit was to eradicate poverty and hunger [United Nations (UN), 2005]. However, over the past several years, progress has been slow and the number of hungry in the developing countries has increased from 799 million in 1998-2000 to 815 million 2000-2002, [Food Agricultural Organization (FAO) 2002a, 2004, and 2005].

Civil wars and conflicts have been associated with food insecurity in the developing world. FAO (2002b), for example, notes that war and civil strife were the major causes in 15 countries that suffered exceptional food emergencies in 2001 and early 2002. Civil strife affect food security in developing countries due its detrimental effects on the agricultural sector and on the economy as a whole. Several studies have been also conducted to determine factors affecting food security in developing countries. Research published by Zhao et al. (1991) has identified factors determining the growth rates of agricultural and food production in developing countries. Specifically, their study involves statistical estimation of an aggregate growth or meta-production function based on cross country and time series data for 28 developing countries. Special attention was devoted to land degradation and pricing policy, and the overall results showed that price distortions in the economy and land degradation had significant negative impacts, while the change in arable and permanent land was positively related to the growth of agricultural and food production from 1971 to 1980. Their research expanded the conventional wisdom supported by a classic article published in 1971 in the *American Economic Review* by Hyami and Ruttan that fertilizer, mechanization etc. were the primary sources of agricultural productivity gains. These expanded results, in turn, emphasized the importance of reducing government induced price distortions or "getting the prices right" and sustainable land and water management practices if the supply side of food security is to be enhanced. Smith et al. (2000) point out a number of factors explaining food security, and discuss the necessary conditions to achieve it. Their paper focuses on why people are food insecure.

Using multiple least squares regressions to examine changes in child hunger rates estimated from the Gomez method (height to weight measures) collected by the World Health Organization, Scanlan and Jenkins (2001) show that, while increased food supply does "trickle down" to reduce child hunger, the effects are quite modest and limited to the more developed least developed countries (LDCs). The poorer LDCs display intractable child hunger that is resistant to economic growth and/or increases in food supply, including international aid and imports. Net of increased food supply, child hunger is also created by a combination of militarism (increased military spending, praetorian government, and arms imports), the ongoing detriment of numerous "food wars" and "military famines," the prevalence of ethnic repression, and the lack of democratization and economic growth. Militarization in the sense of increased military participation and arms production reduced child hunger net of these other regression controls. This earlier work used a conditional change score panel design, so it captured change net of controls for the starting-point in child hunger, and examined 70-75 LDCs between 1970 and 1990. Contrary to views that militarism and militarization are a single integrated process, it found that use of military force to solve political conflicts and the economic role of the military are quite distinct factors and have opposite effects on child hunger.

However, the studies referenced above have not focused on the impact of civil wars on food security. Theoretically, previous studies have analyzed the effects of conflicts on food security (Taeb, 2004; Messer and Cohen, 2004), but failed to provide rigorous empirical evidence. Neither has the rich literature on conflict resolution and correlates of war analyzed the effects of civil wars and internal conflicts on food security. As Messer and Cohen (2004) argue, food insecurity has rarely been investigated by the studies of the economic correlates of war directly, although they often provide evidence that conflict is strongly related to factors associated with food insecurity.

In this study, we examine the degree to which the prevalence of conflicts affects food security in developing countries. Are impacts of civil wars and conflicts more damaging to food deficit countries than to food secure countries? What are the determinants of food security in developing countries? Addressing these issues is crucial to policymaking decisions, since achieving the other millennium development goals hinges on tackling food insecurity particularly in developing countries.

From a country level perspective, food security can be viewed as the extent to which daily per capita food supply or consumption departs from daily per capita minimum dietary energy requirements. In this study, daily per capita calorie supply as a percentage of daily per capita minimum dietary energy requirements under which a country is eligible for food aid is used as a proxy for food security at a country level. Civil wars and conflicts are measured as the number of battle related deaths per thousand members of a warring population. We use various instrumental variable (IV) panel data estimation techniques including fixed effects IV, generalized two stage least squares, and error component two-stage least squares to estimate the effects of civil wars and conflicts on food security. The empirical results indicate that civil wars and conflicts, and food aid are detrimental to food security in developing countries, but an increase in gross domestic product per capita and using intensive and extensive agricultural practices contribute to enhancing food security. To account for differences among countries, we split the sample into countries with average (across time) per capita food supply higher and lower than the daily per capita minimum nutritional requirement under which a country is eligible for food aid. We find that the negative effects of civil wars and conflicts, and food aid per capita on food security are greater for countries with average daily per capita calorie supply lower than the daily per capita minimum dietary requirement. Also, a highly dense population in those countries tends to make them more food insecure. This paper contributes to three lines of literature: the literature on food security, the literature on civil wars and conflicts, and the applied econometric literature.

The rest of the paper is organized as follows. The next section attempts to explain the channel through which civil wars and conflicts affect food security. In section 3, we show the econometric model. Econometric issues and estimation procedures are presented in section 4. Section 5 describes the data used in the study. The results of the study are explained in section 6. Finally, we present our concluding remarks in section 7.

Potential effects of civil wars and conflicts on food security

Conflicts tend to affect food security by creating food shortages, which disrupt both upstream input markets and downstream output markets, thus deterring food production, commercialization and stock management. Depending on the location of the fights in a country, crops cannot be planted, weeded or harvested, decreasing dramatically the levels of agricultural production. In conflict situations, food-producing regions experience seizing or destroying of food stocks, livestock and other assets, interrupting marketed supplies of food not only in these regions but also in neighboring regions. These predatory activities diminish food availability and food access directly, because both militias and regular armies in the field tend to subsist by extorting the unarmed populations for food and any other productive resources. Any food that the militias and armies cannot use immediately in the contested areas will be destroyed to prevent their adversaries from accessing it.

Bearing these risks in mind, the farming populations tend to flee, decline or stop farming. Agriculture may be reduced to subsistence and survival production by farmers who manage to stay, because there is no incentive to invest deeply in production. Recruitment of young male men into militias and thousands of battle-related deaths not only will reduce family income but also take away labor from agriculture. It may become more difficult for small farmers to rely on cash crops such as cocoa and coffee as their income sources due to either desertion of belongings in the face of threatening rebels or prevention from transporting the commodities to local markets. An example is in Ivory Coast where farming fared poorly during the months following October 2002, when government and rebel forces engaged in combat. Cocoa and coffee farmers fled their holdings because of rebels' threats, and cotton farmers in the North were short of income owing to their failure to transport their product to the port of Abidjan (Taeb, 2004).

Another way conflicts result in food shortage is through landmines. Due to landmines, agricultural lands become inaccessible for years, harvests are destroyed and fields cannot be cultivated. Rural populations that depend on these fields for food are prevented from farming, therefore creating a breech in agricultural and food production (Messer et al. 2000).

In sum, food security is best served when the institutional environment prevalent in the developing countries guarantees security, stability and order. No promotion for savings, investment, and capital formation can be made in an environment where long-term private and public investments cannot be planned and carried through. The problem of physical insecurity and property rights may hold back incentives to invest in either production or research aimed at benefiting the agricultural sector and consumers.

Econometric model

Conceptually, this study relies upon the concept of the meta-production function advanced by Hayami and Rattan (1971) and used by Lau and Yotopoulos (1987), by Zhao et al. (1991) and others. The meta-production function is adapted to include some agricultural inputs to allow for intensification and extensification practices. Variables such as civil unrest and democracy represent government policies or institutional environment necessary to provide conditions for attaining food security. An exhaustive list of the explanatory variables used in the study is given in section 5.

Given our interest in investigating the extent to which civil wars and conflicts are detrimental to food security, we specify the following model:

$$Y_{it} = W_{it}\gamma + X_{1it}\beta + \mu_i + \nu_{it} \qquad (1)$$

where Y_{it} is the log of per capita calorie supply as a percentage of minimum per capita calorie requirement under which a developing country is qualified for food aid, W_{it} is the number of battle related deaths per thousand people in year t and in country i, X_{1it} represents a vector of exogenous variables determining food security, μ_i is the country unobserved fixed effects, ν_{it} is the idiosyncratic error term with mean zero and variance σ_v^2, and $\delta = (\gamma, \beta)$ are parameters to be estimated. Note that implicit in the specification is the assumption that the economic relationship is the same for all countries.

The presence of individual heterogeneity, μ_i, indicates that the civil wars and conflict variable may be correlated with country characteristics that also affect food security. In addition, as suggested by previous studies (Kang and Meernik, 2005), W_{it} may be endogenous with respect to v_{it}. One source of this type of correlation is obviously simultaneity between Y_{it} and W_{it}. Countries that are able to make food available for their citizens are less prone to conflicts, *ceteris paribus*. This would imply adding another equation to (1) reflecting that civil wars and conflicts may depend on the food security level in developing countries. However, since our interest is on equation (1), we do not need to add another equation explicitly, but instead to find some instrumental variables. Wooldridge (2002) argues that the most convincing way to obtain such instruments is to use exclusion restrictions in the structural equation (1). This means finding exogenous variables that do not appear in equation (1), but do affect civil wars and conflicts. These variables are called excluded instruments. In this study, we choose our instruments based on the theory of civil war and conflicts and previous studies (Collier, 2000; Collier and Hoeffler, 2000; Collier et al., 2001; Kang and Meernik, 2005).

The theory of civil war states that war is driven by greed or grievance, or a combination of both. As a result, for the civil wars and conflicts variable, we consider five instruments related to greed and grievance. The first instrument is gross domestic product (GDP) per capita growth. The rationale for using this instrument is that the lower the growth rate of GDP per capita in a developing country, the higher the risk of conflict. As Collier (2000) find out, each percentage point off the growth rate of per capita income raises the risk of conflict by around one percentage point. The second instrument is urban population growth. Two reasons explain the basis for this instrument. First, in urban areas, wars are more likely to last longer and to be more deadly. Second conflicts are more likely to arise in countries with fast growing population. The third instrument is the level of ethnic fractionalization. This is measured by the ethnolinguistic fractionalization index, which measures the probability that two randomly selected individuals from a given country do not speak the same language (Collier et al., 2001). A high level of fractionalization entails a large number of ethnic, linguistic and religious groups in a country. Collier and Hoeffler (2000) argue that high fractionalization should impede mobilization to conflict. The fourth instrument considered is agricultural growth, which is measured by annual changes in crops, livestock production, forestry, hunting and fishing. Conflict is likely to arise and be more intense when these economic activities decline or stagnate over time. The fifth and last instrument used is tropical location. This is justified by the fact that wars are likely to be lengthier and more deadly in countries located in the equatorial rain-forest belt with hot tropical rain much of the year (Kang and Meernik, 2005). However, from a statistical standpoint, the relevance and validity of these instruments are discussed below.

Econometric issues and estimation procedures

We first ignore the endogeneity problem by estimating equation (1) using the ordinary least squares (OLS) estimator and a fixed effects estimator. Second, we take into account both the endogeneity problem and the presence of unobserved heterogeneity or country fixed effects. But the first concern is the appropriateness of an instrumental variable fixed effects estimator relative to an instrumental variable random effects estimator. This question translates to whether to consider the country fixed effects as parameters to estimate which leads to using a fixed effects estimator or whether the effects should be treated as random variables in which case a random effects estimator must be used. This crucial decision rests usually on statistical ground and the data characteristics. The fixed effects estimator is more appropriate when the individual countries fixed effects are assumed to be correlated with the explanatory variables. The random effects model, while more efficient, may be biased and inconsistent when country fixed effects are correlated with explanatory variables.

In this analysis, there are at least two reasons why the fixed effects estimator is more appropriate than the random effects estimator. First, it is implausible to consider our sample of developing countries as being a random sample drawn from the complete list of all countries. Second, it is very unlikely that the country fixed effects are uncorrelated with all of the explanatory variables. For example, the ability to choose the appropriate fertilizer dose is expected to be correlated with fertilizer use par ha. Likewise, soil quality and types in specific countries are likely to be correlated with tractor use. As a result, we consider an instrumental variable (IV) fixed effects estimator.

Let X_{it} = (X_{1it}, X_{2it}) and Z_{it} = (W_{it}, X_{it}), where X_{1it} is as in equation (1) and X_{2it} is a vector of excluded regressors. Then, the IV fixed effects estimator is obtained by a two-stage least squares (2SLS) regression of $\tilde{Y}_{it}$ on $\tilde{Z}_{it}$ using $\tilde{X}_{it}$ as instruments, where the squiggled variables are within transformation of the original variables. The within transformation of a given variable w_{it} is as follows:

$$\tilde{w}_{it} = w_{it} - \overline{w}_{i.} \qquad (2)$$

where

$$\overline{w}_{i.} = \frac{1}{T_i}\sum_{t=1}^{T_i} w_{it} \qquad (3)$$

T_i is the number of observations for country i. In matrix form, the IV fixed effects estimator or Within two stage least squares estimator can be expressed as follows:

$$\hat{\delta}_{IVFE} = (\tilde{Z}' P_{\tilde{X}} \tilde{Z})^{-1} \tilde{Z}' P_{\tilde{X}} \tilde{Y}\ , \qquad (4)$$

which is equal to?

$$\hat{\delta}_{IVFE} = [Z'QX(X'QX)^{-1}X'QZ)]^{-1}[Z'QX(X'QX)^{-1}X'QY]\,, \quad (5)$$

where

$$P_{\tilde{X}} = \tilde{X}(\tilde{X}\tilde{X}')^{-1}\tilde{X}' \qquad (6)$$

$$Q = diag(E_{T_i})\,, \qquad (7)$$

where $E_{T_i} = I_{T_i} - J_{T_i}/T_i$, where J_{T_i} is a matrix of ones with dimension T_i. Q is an idempotent matrix performing the Within transformation.

We also estimate a generalized method of moments (GMM) version of the IV fixed effects model by applying a two step GMM on the transformed data (Baum et al., 2003; Cameron and Trivedi, 2005). IV-GMM is more efficient in the presence of panel level heteroskedasticity.

Even though we ground the choice of the instruments on theory and previous studies, that does not mean they are valid and relevant from a statistical standpoint. Further investigations are needed to ensure that they are adequate. For this purpose, a number of tests were performed. First, an instrument relevance test is carried out using the Anderson canonical correlations likelihood-ratio test statistic, which tests whether the structural equation is identified, meaning that the excluded instruments are relevant (Hall et al., 1996; Anderson, 1984). The null hypothesis for this test is that the rank of the matrix of reduced form coefficients is lower than the number of regressors, meaning that the equation is unidentified. Under the null of hypothesis of underidentification, the statistic is distributed as chi-squared with degrees of freedom equal to (L-K+1) where L is the number of instruments (included + excluded) and K is the number of included instruments. A failure to reject the null indicates that instruments are weak. However, even with a rejection of the null hypothesis, weak instruments may still be a problem. A closely related test statistic is the Cragg-Donald chi-squared (Cragg and Donald, 1993). Stock and Yogo (2002) suggested the F-statistic form of the Cragg-Donald statistic as a test for weak instrument. The null hypothesis is that the structural equation is only weakly identified.

Second, we conduct a Hansen-Sargan test of overidentification restrictions which tests the null hypothesis that the instruments are valid, i.e. uncorrelated with the disturbances terms and that the excluded instruments are correctly excluded from the estimated equation. Under the null hypothesis, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. Rejecting the null implies that the instruments may not be valid. Third, we perform a redundancy test to assess whether it is worth considering the extra variables as instruments. Redundant instruments can be interpreted loosely as those that do not yield extra gains in asymptotic efficiency.

To conduct the aforementioned tests, we consider four combinations of the excluded instruments using the IV fixed effects estimator. Only the instrument subset consisting of GDP per capita growth, urban population growth and agricultural growth passed the overidentification test. Therefore, the analysis is carried out with this subset of instruments for the civil war and conflicts variable.

In the presence of endogeneity, while the IV fixed effects estimates are consistent, they are not efficient. If the difference between the IV fixed effects estimates and the (OLS-estimated) fixed effects estimates is significant then the former are preferred. However, if there is no difference between the two then more efficient estimates (the latter) must be chosen. Lastly, an endogeneity test was undertaken to determine whether the IV estimates are significantly different from the (OLS-estimates) fixed effects estimates.

We need to address some issues associated with estimating fixed effects models. First, coefficients on important time-constant exogenous variables are unidentified due to perfect multicollinearity[1]. Relatedly, parameters on variables changing sluggishly over time will be hard to estimate precisely. The reason is that these variables[2] will be highly correlated with the individual country fixed effects. Their estimated coefficients may be very imprecise. Other argument in favor of the random effects estimator is that it allows exploiting all information about the countries even those with single observations (Biørn 1981). In a cross-country analysis, Grossman and Krueger (1995) use the random effects estimator to account for the unbalanced nature of their panel data. Nevertheless, under certain conditions, as will be seen later, the fixed effects estimates coincide with the random effects estimates. We estimate four random effects models in addition to the fixed effects models. The four IV random effects models differ in the way the variance components are estimated and the set of instruments used. To estimate the variance components, we use the Swamy-Arora (1972) method expanded to unbalanced panel data by Baltagi and Chang (1994) and the simple consistent covariance estimates by Baltagi and Chang (2000). The difference in the two lies in the fact the former makes a small sample correction of the degree of freedom, while the latter does not. As in equation (1), let the combined error terms be

$$u = \mu_i + \nu_{it}, \qquad (8)$$

then, based on Baltagi and Chang (2000) and under the assumption of the random effects model,

[1] Due to its time-constancy, the tropical location variable cannot be used as an instrument in fixed effects regressions.
[2] These variables will be close to zero when time-demeaned.

$$\Omega = E(uu') = \sigma_v^2 diag\left[I_{Ti} - \frac{1}{T_i} i_{Ti} i_{Ti}^{'} \right] + diag\left[w_i \frac{1}{T_i} i_{Ti} i_{Ti}^{'} \right]. \qquad (9)$$

Therefore,

$$\sigma_v \Omega^{-1/2} = diag\left[I_{Ti} - \frac{1}{T_i} i_{Ti} i_{Ti}^{'} \right] + diag\left[\sqrt{(\sigma_v^2 / w_i)} \frac{1}{T_i} i_{Ti} i_{Ti}^{'} \right], \qquad (10)$$

where i_{Ti} is a vector of ones of dimension T_i and $w_i = T_i \sigma_\mu^2 + \sigma_v^2$

Pre-multiplying each variable by equation (10) yields the generalized least squares (GLS) transformation of the data. The GLS transformation of a given variable is expressed as follows:

$$w^* = w_{it} - \hat{\lambda}_i \overline{w} i. \qquad (11)$$

where

$$\overline{w}_{i.} = \frac{1}{T_i} \sum_{t=1}^{T_i} w_{it} \qquad (12)$$

and $\hat{\lambda}_i$ is a consistent estimate of $\lambda_i = 1 - \left[\frac{\sigma_v^2}{\sigma_v^2 + T_i \sigma_\mu^2} \right]^{1/2}$. (13)

Rewriting $\hat{\lambda}_i$ as

$$\hat{\lambda}_i = 1 - \left[\frac{1}{1 + T_i \left(\frac{\hat{\sigma}_\mu^2}{\hat{\sigma}_v^2} \right)} \right]^{1/2} \qquad (14)$$

indicates that $\hat{\lambda}_i \to 1$ as $T_i \to \infty$ or as $\hat{\sigma}_\mu^2 / \hat{\sigma}_v^2 \to \infty$. Given T_i, fixed effects estimates may be close to random effects estimates if the estimated variance of μ_i is large relative to the estimated variance of v_{it}. The advantage of using the random effects estimator when variables are time-constant becomes less striking. As $\hat{\lambda}_i$ approaches unity, the precision of the random effects estimator approaches that of fixed effects. As a result, the effects of time-constant variables and variables changing slowly over time become harder to estimate. Due to the unbalancedness of the data, two-way effects models cannot be estimated. Nor is it possible to include a time trend. The estimated time effects would not represent the period effects for all countries.

Implementing feasible generalized least squared (FGLS) requires consistent estimates of the unknown variance components. The extension of the Swamy-Arora method by Baltagi and Chang to unbalanced panel data is given as follows:

$$\hat{\sigma}_{\upsilon} = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T_i}\tilde{u}_{it}^{2}}{N-n-K+1} \quad (15)$$

$$\hat{\sigma}_{\mu} = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T_i}\bar{u}_{it}^{2}-(n-K)\hat{\sigma}_{\upsilon}^{2}}{N-r} \quad (16)$$

where $\tilde{u}_{it}$ and $\bar{u}_{it}$ are the estimated residuals for the within group and between group regressions, and

$$r = Trace\{(\bar{Z}_i^{'}Z_i)^{-1}\bar{Z}_i^{'}Z_{\mu}Z_{\mu}^{'}\bar{Z}_i \quad (17)$$

where $$Z_{\mu} = diag(i_{T_i}i_{T_i}^{'}), \quad (18)$$

and $\bar{Z}$ is the vector of instruments after they have been passed through the between transformation. The between transformation of a variable *w* is given as follows:

$$\bar{w}_i = \frac{1}{T}\sum_{t=1}^{T_i} w_{it} \quad (19)$$

The Baltagi and Chang (2000) simple consistent covariance estimates are given by:

$$\hat{\sigma}_{\upsilon}^{2} = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T_i}\tilde{u}_{it}^{2}}{N-n} \quad \text{and} \quad \hat{\sigma}_{\mu}^{2} = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T_i}\bar{u}_{it}^{2}-n\hat{\sigma}_{\upsilon}^{2}}{N} \quad (20)$$

With each of the variance estimation methods, two sets of instruments are used: the instrument set proposed by Balestra and Varadharajan-Krishnakumar (1987) and the Baltagi error component two stage least squares (EC2SLS) instrument set. The former uses X*, which are the original instrument variables (excluded and included exogenous variables) after they have been transformed through the GLS transformation as indicated below. This estimator is termed generalized two-stage least squared (G2SLS).

The latter uses X^* and $\overline{X}$ as instruments, $\overline{X}$ being the group mean of each variable in X_{it}. According to Baltagi and Li (1992), the extra instruments used by the EC2SLS estimator are redundant.

Lastly, to account for country differences in terms of per capita calorie supply, we split the sample into countries with the average per capita calorie supply higher and lower than 2300 kilocalories for the period of analysis. We then re-estimate the IV fixed effects and the IV or random effects models.

Data and variable definition

To conduct the analysis, we use a macro panel dataset consisting of 73 countries[3] over the period 1970-2002. We focus on developing countries grouped in five world regions: East Asia (EA), Near East and North Africa (ENA), Latin America and Caribbean (LAC), South Asia (SA) and Sub-Saharan Africa (SSA). Because cross-national data on food security from nationally representative household surveys are not available, we use daily per capita calorie supply, which is one of the main determinants of food security to construct a proxy for food security at the country level. Daily per capita calorie supply as a percentage of minimum dietary energy requirements is used in this study as a proxy for food security. The United States Agency for International Development (USAID) set for the daily per capita minimum nutrient intake a threshold of 2300 kilocalories under which a country is qualified for food aid.

All economic data are from the Food and Agricultural Organization's statistical database (FAOSTAT)[4] and the World Bank's World Development indicators (WDI) dataset. The PRIO/Uppsala armed conflict dataset in its expanded version by Lacina and Gleditsch (2005) is used for civil wars and conflicts. To construct the civil war variable, we use their best estimates of battle related deaths due to internal and internationalized conflicts. An internal conflict occurs between two opposite parties of a state

[3] Countries included in the study are the following: Algeria, Angola, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Chad, Chile, Colombia, Congo Democratic Republic (former Zaire), Congo Republic, Costa Rica, Cote d'Ivoire, Dominican Republic, Ecuador, Egypt Arab Republic, El Salvador, Fiji, Gabon, The Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, India, Indonesia, Iran Islamic Republic, Jamaica, Kenya, Korea Republic, Lao PDR, Libya, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Tanzania, Thailand, Togo, Tunisia, Uganda, Uruguay, Venezuela, Yemen Republic, Zambia, Zimbabwe.

[4] See: http://faostat.fao.org/default.aspx?alias=faostatclassic

or a country without intervention of external forces, while an internationalized conflict occurs between two opposite parties of a state with the intervention of external forces. Data for democracy/autocracy are from the Polity IV project[5]. Ethnic fractionalization data are from Krain (1997).

Countries with missing observations for the whole period for some key variables such as per capita calorie supply (which is used to construct the proxy for food security) and food aid per capita are excluded from the analysis. Figure 1 shows the geographical distribution of the countries included in the sample. Due to missing observations on some variables for some countries, we analyze an unbalanced panel data with the degree of unbalancedness equal to 0.84[6]. As Baltagi and Chang (2000) mention, making the data balanced to simplify the computations may result in important loss of root mean square error. The number of observations per country varies from 12 to 33, except for Namibia and Cambodia which display four and five observations respectively. A common way of analyzing panel data with large T is to use five-year or 10-year averages of the data in order to reduce business-cycle effects and measurement error. Due to the unbalanced nature of our dataset, this is not possible. In fact, Attanasio et al. (2000) recommend against this procedure, which throws away too much information.

While Table 1 presents the list of the variables and their expected relationships with the food security variable, Table 2 shows the minimum, mean and maximum values of some key variables by region. All variables are log transformed except civil wars, regime type (democracy/autocracy), and population growth. Figure 2 displays the annual average per capita calorie supply across regions.

As stated at the beginning of the paper, a negative impact of civil unrest on food security is expected. We are now hypothesizing the relationship between food security and other variables. Because intensive agricultural practices such as applying fertilizers, maintaining irrigation systems and using agricultural machinery are yield enhancing, they are expected to positively affect food security. Extensive

[5] **http://www.cidcm.umd.edu/inscr/polity/index.htm**

[6] According to Ahrens and Pincus (1981), and Baltagi and Chang (2000), the degree of unbalancedness is measured by $DU = \frac{n}{\bar{T}\sum_{i=1}^{n} 1/T_i}$, where n is the number of group and $\bar{T} = \frac{1}{n}\sum_{i=1}^{n} T_i$

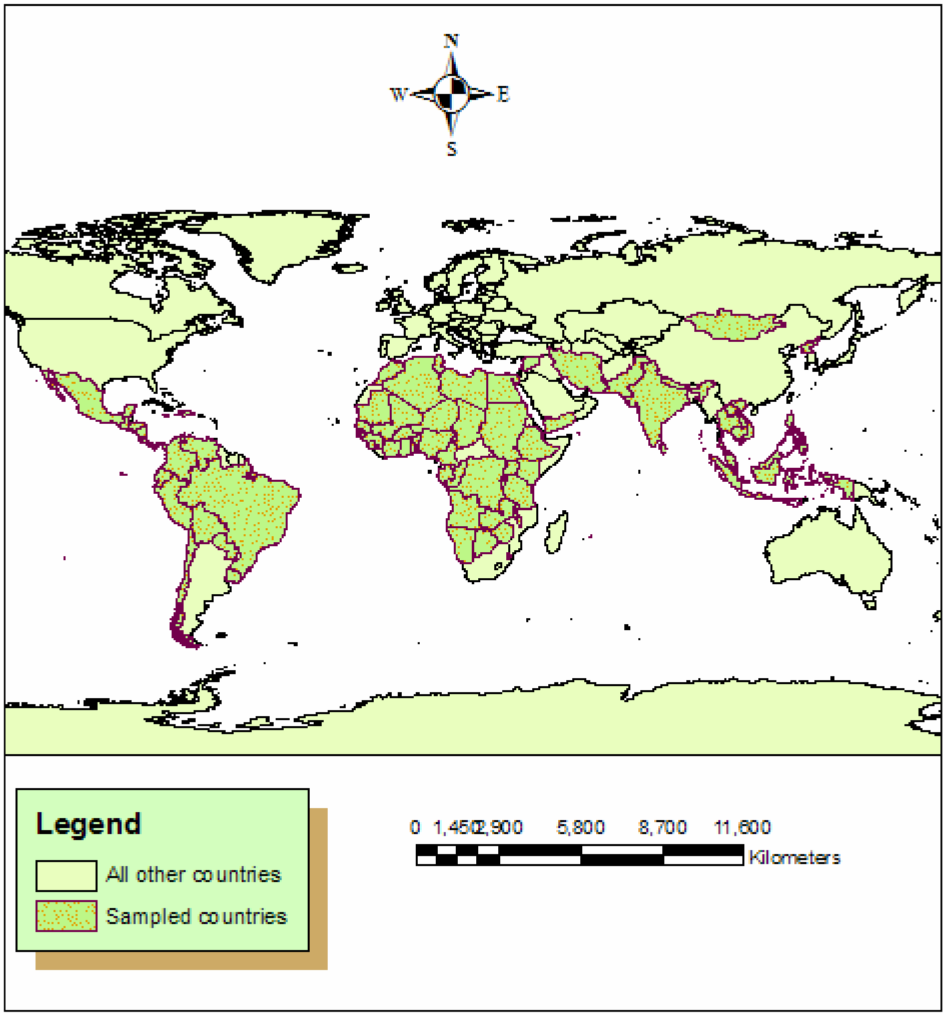
agricultural practices where land resources are abundant are expected to boost food security. However, if farmers are forced to extend low-intensity farming practices onto newly cleared and plowed lands because the natural resource base is distinctively resistant to easy intensification, environmental degradation may result. We use arable land as a percentage of land area and its squared term to evaluate these contentions.

In situations of natural and man-made crises, or to support developing countries with chronic food deficits, food aid can be viewed as the most direct and immediate way to help the needy. However, a divergent view on the impact of food aid on a country local conditions exists in the literature. Schultz (1960) and Tweeten (1999) maintain that food aid may have a disincentive impact on local farmers. Barret (2002), however, argues that food aid has very little effect on local production, but instead imports are displaced. Based on these arguments, the sign on food aid per capita is unclear. Food aid is measured in metric tons per capita to account for population effects.

According to neo-classical economic theory, economic development/growth is expected to benefit unfortunate countries. We include per capita gross domestic product (GDP) to account for commercial imports of food from international markets. Thus, we anticipate a positive relationship between food security and gross domestic product (GDP) per capita. Countries with democratic regimes are believed to be more motivated to marshal food for their citizens, as opposed to authoritarian regimes. In fact, many studies, Drèze and Sen (1989) and Sen (1981) for example, have shown the importance of democracy in averting hunger. Democracy is thus expected to be positively related to food security. The democracy/autocracy variable ranges from -10 to + 10 to represent highly autocratic to highly democratic countries.

A highly dense rural population is important for agricultural intensification. If labor is lacking in rural areas, then it becomes difficult for governments in developing countries to justify investments aimed at promoting agricultural infrastructure such as all-weather roads, irrigation, and electricity. However, a highly dense rural population may be detrimental to promoting agricultural development. Fragmentation of agricultural land and over use of rural infrastructure may lead to low productivity in the agricultural sector. As a result, we expect either a positive or a negative relationship between rural population density and food security.

Figure 1: Geographical Distribution of the Sample



Not only is population growth the major reason for increased food requirement, it also contributes to environmental stresses. Because of high population growth rate in developing countries, more land is needed to accommodate the growing number of people. As a result, there is a competition for land among farming, housing and other uses. Human innovations and technological advances are needed to allow food production to keep up with population growth. As this is not the case for most developing countries, a negative relationship is expected between food security and population growth. In other words, countries with more rapid population growth are expected to face more challenges in enhancing food security.

Table 1: Variable Definition and Descriptive Statistics

Variable	Definition	Expected sign	Obs	Mean	Std. Dev.	Min	Max
cal	Per capita calorie supply (calories)		2508	2325.5	370.72	1510.2	3477.9
fdsec	Per capita calorie supply (% of caloric supply required for food aid)		2508	101.11	16.12	65.66	151.21
Independent variables							
death1000	Deaths per Thousand people	-	2508	0.08	0.58	0.00	19.44
fdcap	Food aid (Ton of cereals per capita)	?	2485	0.01	0.01	0.00	0.14
gdpcap	GDP per capita (Constant 2000 ($))	+	2307	1329.66	1490.42	74.74	11935.79
arabpct	Arable land (% of land area)	+	2485	12.30	11.56	0.19	55.08
fertilha	Fertilizer use (100 grams per ha)	+	2422	649.95	1092.61	0.26	8844.44
irrigpct	Irrigated land (% of cropland)	+	2465	12.59	17.89	0.03	100.00
tractha	Tractors per ha of arable land	+	2485	0.64	0.96	0.00	12.25
ruraldens	Rural pop density (People per sq km)	-/+	2485	342.94	263.42	19.83	1649.50
polity2	Level of democracy/autocracy	+	2454	-1.53	6.72	-10.00	10.00
popgwth	Population growth (annual %)	-	2508	2.42	1.19	-36.68	21.76
List of instruments		Effects on civil war					
gdppcg	GDP per capita growth (Annual %)	-	2290	1.19	5.57	-43.65	35.49
agrgwth	Agricultural, value added (Annual % growth)	-	2235	2.87	9.36	-49.58	78.01
krethno	Ethnic fractionalization	-	2426	0.52	0.24	0.01	0.86
tropics	Dummy=1 if tropical location	+	2508	0.80	0.40	0.00	1.00
urbpopg	Urban population growth (annual %)	+	2124	4.30	2.06	0.19	32.80

Figure 2: Mean Calorie Distribution across Geographic Regions

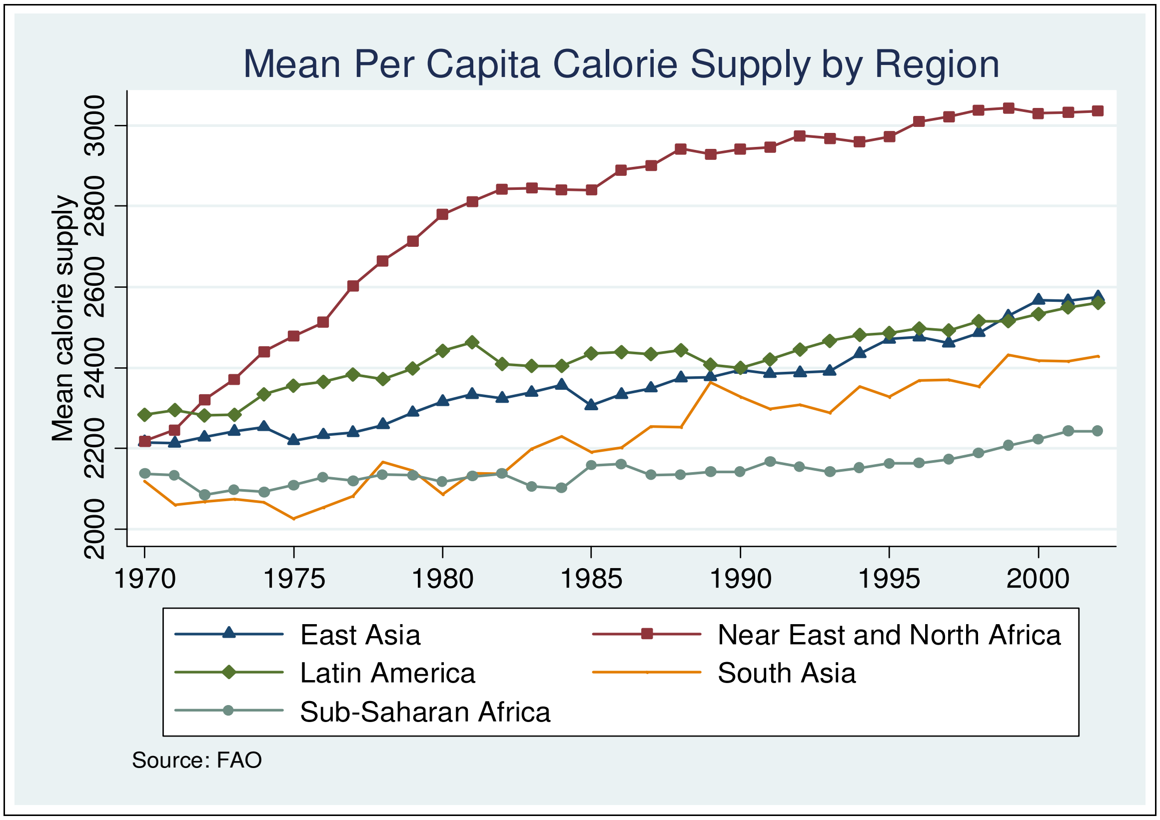


Table 2: Regional Minimum, Mean and Maximum Values of Some Key Variables

Region	Calorie Supply	Civil War	GDP	Arable Land	Fertilizer Use
1	1547.7	0	195.9	0.47	0.29
	2361.51	0.16	1644.22	12.88	1440.52
	3119.5	8.45	11935.79	35.1	7725.27
2	1768.9	0	418.58	0.98	0.75
	2793.08	0.18	1681.72	11.56	832.15
	3477.9	19.44	6872.8	31.08	4577.85
3	1731.8	0	469.6	1.44	3.89
	2424.17	0.05	2410.63	9.86	874.54
	3261.3	2.59	6528.12	32.66	8844.44
4	1768	0	138.97	12.53	27.44
	2230.49	0.04	361.63	27.86	892.77
	2495.1	0.8	884.38	55.08	3102.82
5	1510.2	0	74.74	0.19	0.26
	2147.16	0.05	633.47	11.85	192.28
	2963.2	2.24	7782.59	49.26	3772.7
Total	1510.2	0	74.74	0.19	0.26
	2325.49	0.08	1329.65	12.3	649.95
	3477.9	19.44	11935.79	55.08	8844.44

Results and discussions

We first present in Table 3 the estimated coefficients[7] from the regressions ignoring the endogeneity nature of the civil war and conflicts variable. As can be seen, the coefficients on the civil war variable (*DEATH1000)* estimated from the two models have the expected sign; but they are both biased and inconsistent, unless endogeneity with respect to the idiosyncratic error term is not a problem. The fixed effects estimated coefficient is not even significant. This is due to failure to account for endogeneity, given that the consistency of the fixed effects estimator hinges on strict exogeneity of the explanatory variables conditional on the unobserved heterogeneity. Compared to the fixed effects estimates, the OLS estimated coefficients on per capita GDP (*GDPCAP*), the percentage of arable land (*ARABPCT*), and irrigated land as a percentage of crop land (*IRRIGPCT*) are downward biased, implying that the country fixed effects are negatively correlated with these explanatory variables. It is worth noting that all of fixed effects estimated coefficients have the expected signs.

Table 3: Regression results ignoring endogeneity

Variable	OLS		FE	
	Coefficients	Std errors	Coefficients	Std errors
death1000	-0.0700***	(0.0164)	-0.0043	(0.0114)
Log fdcap	0.0007	(0.0012)	-0.0032***	(0.0010)
Log gdpcap	0.0511***	(0.0059)	0.1133***	(0.0149)
arabpct	0.0040***	(0.0010)	0.0184***	(0.0042)
arabsq	-0.0001***	(0.0000)	-0.0002***	(0.0001)
Log fertilha	0.0173***	(0.0034)	0.0163***	(0.0043)
Log irrigpct	0.0066**	(0.0028)	0.0298***	(0.0111)
Log tractha	0.0164***	(0.0035)	0.0104	(0.0079)
Log ruraldens	-0.0299***	(0.0052)	-0.0187	(0.0222)
polity2	-0.0039***	(0.0006)	0.0006	(0.0005)
popgwth	-0.0049	(0.0038)	-0.0021	(0.0036)
Intercept	4.3436***	(0.0611)		
N	2133		2133	
Adjusted R^2	0.5253		0.2255	
RMSE	0.1037		0.0697	

Legend: *: significant at the 10%; **: Significant at 5%; ***: Significant at 1%

[7] All results in this study are obtained with the software package STATA 9.2

We next turn to our preferred specifications that take into account the endogeneity problem resulting from correlation of the civil war and conflicts variable with both the idiosyncratic error term and the country fixed effects. Recall that, if there are endogenous regressors of the conventional simultaneous equation type, a fixed effects estimator accounting only for unobserved heterogeneity is inconsistent. The results are presented in Table 4. The first two columns are the fixed effects estimates. As can be seen in Table 4, the IV fixed effects GMM estimates are slightly higher in absolute value and have lower standard errors than the IV Fixed effects estimates, as expected. For the civil war variable, notice the striking difference between the estimated coefficient yielded by the fixed effects estimator (-0.0043) and those reported by the IV fixed effects estimators: -0.1639 (IVFE) and -0.1826 (IVFEGMM).

Below the estimated coefficients of the fixed effects models are P-values associated with the test statistics for the relevance and the validity of the instruments, and the endogeneity of the civil war variable. The P-values of the Anderson Canonical likelihood ratio statistic, the Cragg-Donald chi-squared statistic, and the Cragg-Donald F statistic are presented. These results indicate that the structural equation is identified and the instruments are not weak. Consistent with the tests for the instrument relevance, the P-value of the Hansen's J statistic suggests a failure to reject the joint null hypothesis that the instruments are valid instruments, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. However, the P-value of the likelihood ratio statistic for a redundancy test of the extra instruments in the instrument set indicates a failure to reject the null hypothesis that the extra instruments are redundant. This result is in sharp contrast with the results of the tests for the instrument relevance and validity and may be due to the assumption of the redundancy test that the regressors are distributed as multivariate normal, which is very unlikely. In addition, the regression results are valid since there are still sufficient nonredundant instruments (Cameron and Trivedi, 2005). The endogeneity test rejects at the five percent significance level the null hypothesis that the civil war variable can actually be treated as exogenous. The tests for instrument relevance and validity also indicate that the tropical location variable is incorrectly excluded from the structural equation. Therefore, we include it in the estimation of the structural equation when appropriate.

The next two columns in Table 4 display the G2SLS parameter estimates with (IVGLS) and without (IVNOSA) small sample adjustment of the variance component estimator. The two sets of estimates are nearly identical, so are the two overall R-squares. The last two columns are the Baltagi's EC2SLS with and without the small sample adjustment. Again notice the similarity between the two sets of estimates. This result is not surprising given the sample size used in the study. However, for the instrumented variable, compared to the G2SLS estimator, the EC2SLS estimator yields larger parameter estimates in terms of magnitude. Note that the efficiency of the estimation is not improved by using the Baltagi's extra instrument set, supporting the claim of Baltagi and Li (1992) that these instruments are redundant à la White (1986).

It worth noting that IV random effects estimates for the civil war variable (*DEATH1000*) are also higher, with the EC2SLS estimates much higher, in absolute value, than those reported by fixed effects: -0.1584 and -0.1577 for the IVGLS; and -0.2741 and -0.2833 for the EC2SLS estimates as compared to -0.0043. These results glaringly pinpoint the danger of using conventional panel data models when endogeneity is of conventional type, i.e. with respect to the idiosyncratic error term. Baltagi (2006) found similar results when replicating results in Cornwell and Trumbull (1994).

While the estimated coefficients on the log transformed explanatory variables represent elasticities, the coefficients on population growth (*POPGWTH*) and arable land as a percentage of cropland (*ARABPCT*) need to be multiplied by 100 to represent the percentage change in the dependent variable when these variables change by one unit, which is, in this case, one percentage point. But, for variables such as civil war (*DEATH1000*), tropical location (*TROPICS*) and the level of democracy/autocracy (*POLITY2*), the exact percentage change in the dependent variable due to one unit change in these variables is given as follows (Wooldridge, 2003):

$$\%\hat{\Delta} fd\sec = 100[\exp(\hat{\beta}) - 1], \qquad (21)$$

where $\hat{\beta}$ is the estimated coefficient on the specified variable.

At the outset, it is worth noting that the sign on the parameter estimates in all columns are generally in line with expectations, and most variables have a statistically significant impact on food security. For several variables, the fixed effects estimates and the random effects estimates are nearly identical in terms of magnitude and significance level. Interestingly, the coefficients on *DEATH1000* are as expected and highly significant in all models, and larger in magnitude, compared to those estimated by the models ignoring endogeneity of *DEATH1000.* This result suggests that ignoring endogeneity of *DEATH1000* leads to biased parameter estimates and civil war and conflicts are likely to decrease food security in developing countries. On average, one more battle-related death would reduce calorie supply as a percentage of minimum dietary energy requirements by 15%-25%.

The coefficients on food aid per capita (*FDCAP*) are negative and highly significant in all models, indicating that providing more food aid to the developing countries tends to reduce their food security level. This result supports the argument by Schultz (1960) and Tweeten (1999) that food aid tends to discourage local food production because of a resulting drop in the local prices. One possible explanation for this result is that food aid may not have been given to the neediest countries. Donating food aid to countries already experiencing food surplus may cause local prices to fall, discouraging the local farmers. Another explanation is that food aid supporting some "food for work" programs may have driven rural labor out of agricultural production. Still another reason is endogeneity. Countries with food security problems tend to receive more food aid. To evaluate this argument, an exogeneity test was performed for the food aid per capita (*FDCAP)* variable. With a Chi-squared statistic equal to 0.238 and a P-value equal to 0.6257, the test fails to reject the null hypothesis that *FDCAP* can be treated as exogenous.

The estimated coefficients on *GDPCAP* in all models have the expected sign and are highly significant despite the cautious warning put forth by Smith and Haddad (2000) that when both income and variables that income determine are included in a regression model, the coefficient on income drops significantly and become statistically insignificant. This result is consistent with the argument that economic development is conducive to food security. Both arable land (*ARABPCT*) and arable land squared (*ARABSQ*) are significant predictors of food security, suggesting an increase in food security with arable land as a percentage of land area, but at a declining rate, as anticipated. From the estimated parameters, the turning point with respect to arable land as a percentage of land area is approximately 34% - 36%, which is between the mean and the maximum values, as shown in table 2. This result indicates that, after the turning point, extending arable land is detrimental to food security due maybe to environmental degradation. The sign and significance level of variables such as fertilizer use (*FERTILHA)*, *IRRIGPCT*, and tractor per hectare of arable land (*TRACTHA)* imply that using intensive agricultural practices are food security enhancing. It is worth noting, however, the fixed effects estimates display a stronger impact of irrigation on food security, so do the random effects estimates for tractor per hectare of arable land. The result implied by the intensive agricultural practices is intuitive and does not call for further elaboration.

The sign on the rural population density (*RURALDENS*) and population growth (*POPGWTH*) variables is negative, but only the random effects models show highly significant coefficients. It was theorized that high population density may have either a positive or negative impact on food security depending on how the agricultural sector is affected. This result suggests that having more people per square kilometer in the rural areas tends to make developing countries more food insecure. The sign and the significance level of the coefficients on *POPGWTH* imply that countries with rapid population growth face more difficult challenges ensuring food security, as expected. The democracy/autocracy variable (*POLITY2*) has the expected sign, but only the estimates given by the G2SLS estimators show a significant impact. A theoretical explanation is that this variable changes very sluggishly over time.

Finally, the tropical location *(TROPICS)* variable shows a negative sign, but the coefficients are significant only in one model. The sign indicates that being located in the tropics has a negative impact on food security. This result is as expected, since countries located in the tropics are more prone to diseases and have less productive land. More explanation for this result can found in Meier and Rauch (2005) with which this result is consistent.

Table 5 displays results for Hausman tests based on the difference between the fixed effects 2SLS and the random effects 2SLS, as proposed in Baltagi (2004). The conventional Hausman test comparing FE and RE estimators in classical panel data regression is generalized to test the null hypothesis $H_0 : E(u \mid Z) = 0$ based on $\hat{q}_{ij} = \hat{\delta}_i - \hat{\delta}_j$, where *i=IVFE, IVFEGMM* and *j=IVGLS, IVGLSNOSA, EC2SLS, EC2SLSNOSA*. Note that the null hypothesis takes into account endogeneity coming from correlation of the explanatory variables not only with the country fixed effects but also with the idiosyncratic error terms. This means that when endogeneity is also of the conventional simultaneous equation type, the usual Hausman test comparing FE to RE is invalid. The Hausman test statistic is given by:

$$m_{ij} = \hat{q}_{ij}^{'} [Var(\hat{q}_{ij})]^{-1} \hat{q}_{ij}, \qquad (22)$$

where

$$Var(\hat{q}_{ij}) = Var(\hat{\delta}_i) - Var(\hat{\delta}_j) \qquad (23)$$

Under H_0, m_{ij} is asymptotically distributed as $\chi^2(d)$, where d is the number of time varying variables in Z. The results show that for the random effects 2SLS using the degree of freedom adjusted consistent estimated variance components, the null hypothesis that these procedures yield consistent estimators is not rejected at the five percent significance level. However, when the estimated variance components are not adjusted to account for small sample, the tests reject the null hypothesis that the random effects 2SLS yield consistent estimators. Baltagi (2006) carries out a Hausman test, which compares IVFE with EC2SLS (with small sample-adjusted estimated variance components) finds that the test failed to reject the null hypothesis that EC2SLS yields a consistent estimator.

Table 4: Regression Results with Endogeneity

Variable	IVFE	IVFEGMM	IVGLS	IVNOSA	EC2SLS	NOSAEC2SLS
	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients
death1000	-0.1639**	-0.1826**	-0.1584***	-0.1577***	-0.2741***	-0.2833***
	(0.0774)	(0.0741)	(0.0587)	(0.0589)	(0.0593)	(0.0594)
Log fdcap	-0.0026***	-0.0025**	-0.0023***	-0.0022***	-0.0019**	-0.0018**
	(0.0010)	(0.0010)	(0.0008)	(0.0008)	(0.0008)	(0.0009)
Log gdpcap	0.0996***	0.0977***	0.0792)***	0.0770)***	0.0718)***	0.0694)***
	(0.0171)	(0.0168)	(0.0084)	(0.0081)	(0.0091)	(0.0089)
arabpct	0.0168***	0.0168***	0.0096)***	0.0090)***	0.0093)***	0.0087)***
	(0.0044)	(0.0043)	(0.0016)	(0.0015)	(0.0018)	(0.0017)
arabsq	-0.0002***	-0.0002***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log fertilha	0.0157***	0.0155***	0.0147***	0.0146***	0.0143***	0.0142***
	(0.0044)	(0.0043)	(0.0027)	(0.0027)	(0.0030)	(0.0030)
Log irrigpct	0.0315***	0.0311***	0.0096*	0.0078	0.0109*	0.0092*
	(0.0114)	(0.0113)	(0.0052)	(0.0050)	(0.0058)	(0.0055)
Log tractha	0.0132	0.0138*	0.0150***	0.0150***	0.0168***	0.0168***
	(0.0081)	(0.0081)	(0.0037)	(0.0037)	(0.0041)	(0.0041)
Log ruraldens	-0.0193	-0.0190	-0.0198**	-0.0193**	-0.0197**	-0.0193**
	(0.0224)	(0.0215)	(0.0089)	(0.0086)	(0.0099)	(0.0096)
polity2	0.0005	0.0005	0.0007*	0.0007*	0.0006	0.0006
	(0.0006)	(0.0006)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
popgwth	-0.0063	-0.0065*	-0.0077**	-0.0078***	-0.0105***	-0.0108***
	(0.0038)	(0.0038)	(0.0030)	(0.0030)	(0.0033)	(0.0033)
tropics			-0.0421	-0.0477**	-0.0358	-0.0409
			(0.0259)	(0.0239)	0.0286	0.0266
Intercept			4.0989***	7.2596***	4.1621***	4.1896***
			(0.0871)	(0.0840)	(0.0951)	(0.0924)
N	2133	2133	2133	2133	2133	2133
Overall R^2			0.4996	0.5044	0.4788	0.4794
RMSE	0.0744	0.0755				
Identification test P-value	0.000	0.000				
C-Donald χ^2 P-value	0.000	0.000				
C-Donald F-Statistic	20.8692	20.8692				
Hansen's J P-value[8]	0.6833	0.6833				
Red test P-value	0.3615	0.3615				
Endog. test: χ^2 P-value	0.0040	0.0040				

Legend: *: significant at the 10%; **: Significant at 5%; ***: Significant at 1%
Standard errors in parentheses

Next, we turn our attention to the regression results for countries with average per capita calorie supply lower than 2300 for the period. The test results for instrument relevance and validity are not

[8] These tests were also carried out for the random effects models but not reported here since they are consistent with the tests for the fixed effects models.

reported here since they are in line with those conducted for the whole sample. The regression results are displayed in Table 6, which shows several striking features. First and foremost, the estimated coefficients on *DEATH1000* in all models have remarkably improved in terms of magnitude and they are highly significant. This result suggests that civil wars have a more detrimental impact on countries unable to make available the per capita minimum level of calorie intake set by USAID. The estimated coefficients on *DEATH1000* imply that one more battle related death in these countries is likely to decrease calorie supply as a percentage of minimum dietary energy requirements by approximately 20%-29%. Second, the coefficients on *FDCAP* indicate a slightly higher negative impact of food aid on food security in these recipient countries. This is a counter intuitive result. Third, only *GDPCAP* and *ARABPCT* strongly contribute to increase food security in these countries. As anticipated, food security does not monotonically increase in arable land. The results indicate a turning point approximately equal to 33%-36%, beyond which any arable land extension would result in food security deterioration. Apart from *TRACTHA*, whose coefficients show a significant impact only in the random effects models, food security appears less responsive to agricultural productive inputs in these countries. Fourth, the sign and the significance level of the estimated coefficients on *RURALDENS* suggest that a highly dense rural population tends to aggravate food security in countries with food deficits. Lastly, the coefficients on variables such as *POLITY2, POPGWTH and TROPICS* now display no significant impact.

Table 5: Hausman Test Results Comparing 2SLS Fixed Effects and 2SLS Random Effects

Random Effects (RE) 2SLS	Fixed Effects (FE) 2SLS			
	IVFE		IVFEGMM	
	Chi-Squared	P-value	Chi-Squared	P-value
IVGLS	16.48	0.1241	17.44	0.0954
IVGLS NOSA	19.71	0.0495	20.85	0.0350
EC2SLS	17.81	0.0862	17.13	0.1042
EC2SLS NOSA	20.86	0.0348	20.22	0.0424

NOSA: No degree of freedom adjustment to account for small sample

Table 6: Regression Results for mean calorie supply <2300

Variable	IVFE	IVFEGMM	IVGLS	IVNOSA	EC2SLS	NOSAEC2SLS
	coefficients	coefficients	coefficients	coefficients	coefficients	coefficients
death1000	-0.2271**	-0.2295***	-0.2608***	-0.2637***	-0.3390***	-0.3383***
	(0.0944)	(0.0884)	(0.0622)	(0.0622)	(0.0586)	(0.0568)
Log fdcap	-0.0040**	-0.0040**	-0.0041***	-0.0041**	-0.0039**	-0.0039**
	(0.0018)	(0.0018)	(0.0015)	(0.0015)	(0.0016)	(0.0016)
Log gdpcap	0.1005***	0.0996***	0.0489***	0.0418***	0.0441***	0.0380***
	(0.0225)	(0.0214)	(0.0106)	(0.0096)	(0.0114)	(0.0104)
arabpct	0.0189*	0.0188*	0.0081***	0.0073***	0.0082***	0.0074***
	(0.0065)	(0.0065)	(0.0016)	(0.0015)	(0.0018)	(0.0016)
arabsq	0.0003	0.0003	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log fertilha	0.0098	0.0098	0.0071	0.0064	0.0067	0.0059
	(0.0047)	(0.0047)	(0.0033)	(0.0033)	(0.0037)	(0.0035)
Log irrigpct	0.0173	0.0174	-0.0028	-0.0025	-0.0021	-0.0019
	(0.0158)	(0.0157)	(0.0050)	(0.0044)	(0.0055)	(0.0048)
Log tractha	0.0149	0.0152	0.0154***	0.0146***	0.0178***	0.0168***
	(0.0126)	(0.0123)	(0.0053)	(0.0049)	(0.0057)	(0.0053)
Log ruraldens	-0.0951***	-0.0951***	-0.0440***	-0.0407***	-0.0468***	-0.0431***
	(0.0342)	(0.0342)	(0.0117)	(0.0103)	(0.0128)	(0.0112)
polity2	0.0008	0.0008	0.0008*	0.0008*	0.0008	0.0008
	(0.0008)	(0.0008)	(0.0005)	(0.0005)	(0.0006)	(0.0006)
popgwth	0.0024	0.0019	0.0005	0.0005	-0.0005	-0.0004
	(0.0061)	(0.0057)	(0.0034)	(0.0034)	(0.0037)	(0.0037)
tropics			0.0119	0.0148	0.0238	0.0253
			(0.0392)	(0.0335)	(0.0427)	(0.0362)
Intercept			4.3921***	4.4231***	4.4413***	4.4636***
			(0.1098)	(0.0983)	(0.1188)	(0.1057)
N	1177	1177	1177	1177	1177	1177
Overall R^2			0.1923	0.1838	0.1708	0.1611
RMSE	0.0784	0.0786				

Legend: *: significant at the 10%; **: Significant at 5%; ***: Significant at 1%
Standard errors in parentheses

Finally, we consider the regression results for average per capita calorie supply higher than 2300 kilocalories (Table 7). When restricting the sample to countries with average per capita calorie supply greater than 2300 kilocalories for the period, the IV diagnostic tests indicate that the civil war variable can be treated as exogenous. As a result, we estimate only two regressions: fixed effects and random effects for this subsample. Contrary to expectations, the coefficients on *DEATH1000* show a slightly significant positive impact on food security. This is a puzzling and counterintuitive result. Messer et al. 2000 were also puzzled by the fact that food production appears higher in some countries such as Chad and Uganda during war years. *FDCAP* retains its sign and both coefficients are significant. The estimated coefficients on *GDPCAP* are still positive and significant in both models. The estimated coefficients on *ARABPCT* suggest that extending arable land by one more percentage point would have no effect on food security in these countries. On the other hand, as opposed to the models presented in Table 6, the estimated coefficients on *FERTILHA* and *IRRIGPCT* pinpoint that food security seems to be more responsive to agricultural productive inputs. While the fixed effects estimated coefficient on *RURALDENS* is not significant at the conventional significance level and has a positive sign, the random effects estimated coefficient has a negative sign and is significant only at the 10 percent level. Surprisingly, the coefficients on *POLITY2* now become negative, but are still not significant at the conventional significance level. *POPGWTH* now shows a more significant negative impact. Finally, *TROPICS* still has the expected sign, but its coefficient is not significant at the conventional significance level.

Table 7: Regression Results for Mean Calorie Supply >= 2300 Kilocalories

Variable	FE		RE	
	Coefficients	Std errors	Coefficients	Std errors
death1000	0.0540***	0.0186	0.0342*	0.0190
log fdcap	-0.0026***	0.0010	-0.0021**	0.0008
Log gdpcap	0.0759***	0.0224	0.0704***	0.0132
arabpct	0.0078	0.0074	0.0010	0.0031
arabsq	0.0003	0.0002	0.0001	0.0001
Log fertilha	0.0330***	0.0087	0.0308***	0.0059
Log irrigpct	0.0580***	0.0159	0.0297***	0.0092
Log tractha	0.0167	0.0102	0.0126**	0.0062
Log ruraldens	0.0084	0.0374	-0.0245*	0.0130
polity2	-0.0004	0.0008	-0.0003	0.0005
popgwth	-0.0249***	0.0088	-0.0332***	0.0055
Tropics			-0.0382	0.0361
Intercept			4.1413***	0.1394
N	956		956	
RMSE	0.0634		0.0670	

Legend: *: significant at 10%; **: Significant at 5%; ***: Significant at 1%

Summary and Conclusions

The purpose of this study was to investigate the effects of civil wars and conflicts and various other factors on food security in developing countries. We use per capita calorie supply [as a percentage of the minimum nutritional requirement under which a country is eligible for food aid] as a proxy for food security at the country level. Civil war is measured as the total number of battle related deaths per thousand members of a warring population. Due to the endogenous nature of the civil wars and conflicts variable, various instrumental variable panel data models are estimated. From a statistical standpoint, the results indicate that conducting conventional panel data analysis when endogeneity is of the conventional simultaneous equation type is inappropriate. By providing rigorous empirical evidence, the study contributes to the ongoing debate that civil wars and conflicts are conducive to food insecurity in developing countries. From a policy standpoint, the results indicate that enhancing gross domestic product per capita and using intensive and extensive agricultural practices have positive impacts on food security; but, civil wars and conflicts, food aid, being located in the tropics, a highly dense rural population, and a more rapidly growing population would have negative impacts on food security. The results are consistent with the view that the distorting effects of external subsidized grain flows on agricultural production and trade in recipient countries must be monitored (Messer and Cohen, 2004). When taking into account differences among countries in terms of average (across time) per capita calorie supply, we find that, in less food secure countries, the negative impacts of civil wars and conflicts and a highly dense rural population would be more severe. Similarly, food security is less responsive to agricultural productive inputs in these countries. One reason is that the input-output price ratio may discourage the use of these inputs by poor farmers. On the other hand, in their counterpart more food secure countries, extending arable land would result in no effect on food security. Instead, using more agricultural productive inputs tends to boost food security. Neither would civil wars and conflicts cause a decline in food security in these countries.

These results have implications for meeting the Millennium Development Goals. Specifically, ensuring food security at the country level by reducing the gap between per capita calorie supply and per capita dietary energy requirements requires addressing a number of issues. These include voluntary resettlement of the rural population, stabilizing the developing countries' population, increasing external assistance to agriculture in addition to providing food aid, which should be directed to food deficit countries, and most importantly, guaranteeing a peaceful environment necessary for economic development and safe investment in the agricultural sector. Obviously, more research needs to be done to explain why civil wars and conflicts would boost further food security in countries with food surplus.

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