Economic Shocks and Civil Conflict: An Instrumental Variables Approach

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Abstract: Determining the impact of poverty on the likelihood of civil conflict in less developed countries is difficult because of omitted variable bias and endogeneity. We use exogenous weather variation – as measured in satellite vegetation readings – as an instrumental variable for economic growth in 40 Sub-Saharan African countries during 1983-1999, and estimate that economic growth is strongly negatively related to the incidence of civil conflict: a negative growth shock of 5 percentage points increases the likelihood of major civil conflicts by roughly one-half. This relationship is not significantly different in countries that have higher per capita income, that are more democratic or more ethnically diverse. We use a new and comprehensive dataset of civil conflict in the analysis.

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1. Introduction

In recent years the phenomenon of civil wars has gained increasing attention from academics and policy makers alike. This concern is understandable since civil conflict is the source of immense human suffering: it is estimated that civil wars have resulted in three times the number of deaths as interstate wars during the post-World War II period.[1] The suffering caused by civil wars, however, goes well beyond war-related deaths. The major locus for civil wars in recent years has been Sub-Saharan Africa, where twenty-seven of forty countries suffered from civil conflict during the 1980s and 1990s (PRIO 2002). In the median sub-Saharan country the number of people displaced from their homes as a consequence of civil war between 1994 and 1999 alone runs into the hundreds of thousands.[2]

There is a growing body of research that highlights the association between economic conditions and civil conflict. As Sambanis (2001) points out in a survey of the literature, "economic studies of civil war have successfully identified an empirically robust relationship between poverty, slow growth, and an increased likelihood of civil war and prevalence."[3] However, the existing literature does not adequately address the endogeneity of these economic variables to civil war, and thus does not convincingly establish a causal relationship. In addition to endogeneity, omitted variables – for example, overall government institutional quality – may drive both poor economic growth outcomes and civil conflict, producing misleading cross-country estimates.

In this paper we use exogenous variation in vegetation – which is highly correlated with rainfall – as an instrumental variable for GDP growth, and use this variation to estimate the impact of economic growth on civil conflict. Weather shocks are a plausible instrument for GDP growth in economies that largely rely on rain-fed agriculture, i.e., neither have extensive irrigation systems nor are heavily industrialized. The instrumental variable method makes it credible to assert that this is a causal relationship, rather than simply a correlation. As such this paper relates to the approach recently taken by

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[1] Fearon and Latin 2003.
[2] Sambanis 2001.
[3] Sambanis 2001, 26.

Acemoglu, Johnson, and Robinson (2001), who also employ an instrumental variable estimation method in the context of cross-country empirical growth research.

Sub-Saharan Africa is perhaps the ideal region for this identification strategy. In Sub-Saharan Africa, existing studies show that there is a remarkably strong and nearly linear relationship between satellite vegetation measures and actual precipitation,[4] and we find that weather shocks are in fact closely related to income growth. In fact, we find that our identification strategy is not appropriate for most other regions of the world, since weather is not sufficiently closely linked to income growth.[5] Since, in addition, we have access to detailed vegetation data collected from satellite images since as far back as 1982 for Sub-Saharan Africa, we thus opt to focus on this region. Although our analysis is not global, it is likely to be of exceptional interest from both the research and policy perspectives, since the incidence of civil wars is very high – and has increased in the last two decades – in Africa, affecting most countries in the region, whereas it is has declined or remained stagnant in other regions.

The main empirical findings are as follows. Using the comprehensive new database developed by the Peace Research Institute of Oslo, which employs a threshold of 25 battle deaths to identify a civil war (rather than the 1000 death threshold in existing studies), we find that GDP growth is significantly negatively related to the incidence of civil conflict in sub-Saharan Africa during the period 1983-1999 across a range of regression specifications, including some with country fixed effects. The causal relationship between GDP growth and the incidence of civil wars is extremely strong: a five percentage point drop in annual economic growth increases the likelihood of conflict by 10 percentage points, which amounts to a massive one-third increase in the likelihood of civil war. Other variables that have gained prominence in the recent academic literature on civil war – per capita GDP level, political instability, mountainous terrain, oil exporter status, ethnic diversity, and democracy – do not display a similarly robust relationship with the incidence of civil wars in Africa. Moreover, the impact of income shocks

[4] We discuss Anyamba et al 2002. and Nicholson et al (1990) in greater detail below.
[5] Using rainfall measures in FAO, we find that rainfall variation is not robustly related to income variation in industrial countries, Eastern Europe, Latin America, or the Middle East / North Africa. However, there does appear to be a positive relationship between rainfall and income growth in Asia, and we plan to explore this in the future.

civil conflict is not significantly different in richer, more democratic, more ethnically diverse countries, or more mountainous African countries.

Our results resonate with the findings in Collier and Hoeffler (1998, 2001, 2002) and Fearon and Laitin (2003) that economic variables are the key determinants of civil war, perhaps more important than measures of objective political "grievances". However, what is the causal mechanism that links GDP growth to the incidence of civil wars? Collier and Hoeffler stress the economic opportunities of would-be rebels (usually poor young men), relative to other economic activities, such as farming. Yet Fearon and Laitin argue that "economic variables matter primarily because they proxy for state administrative, military, and police capabilities," and they go on to identify weak military capability and poor quality roads as two key channels linking poverty to civil war.

Our empirical finding that short-term economic shocks dramatically increase the likelihood of civil conflict could potentially be consistent with either explanation. However, we find that neither military expenditures nor road coverage is significantly correlated with GDP growth, which appears to undermine the Fearon and Laitin hypothesis. Our cross-country findings instead suggest that the causal relationship between poverty and civil wars in Africa is most likely to be through another channel: a major negative (positive) income shock is likely to make the life of a guerilla relatively more (less) attractive. Unfortunately, we do not have any direct micro-evidence on the outside income opportunities of would-be rebels that could decisively demonstrate this (and the difficulties of collecting household survey data in areas suffering from armed conflict makes such an exercise extremely problematic).

In the next section of this paper we provide a brief overview of the major findings of the literature on the determinants of civil wars. In Section 3, we describe our data, and, in Section 4, we discuss our estimation strategy. Section 5 contains the empirical results, and the final section concludes.

2. Literature Review

Since Sambanis has already provided a detailed review of the civil wars literature, we do not attempt to be comprehensive here.[6] Instead we focus on summarizing the main findings of recent cross-country studies.

As we mention above, economic growth may affect civil conflict through several channels. First, as in Collier and Hoeffler (1998, 2001, 2002), when income opportunities are better for young men in agriculture or in the local labor market, relative to their expected income gained as a rebel, they should be less likely to take up arms. Collier and Hoeffler argue that civil wars are fundamentally driven by such economic opportunities rather than by political grievances – for instance, repression against particular social groups – and in particular find that slow income growth, low per capita income, natural resource dependence (proxied by primary commodity exports as a percentage of GDP), less male secondary education enrollment, rebel military advantages (proxied by dispersed population), and total population are all significantly positively associated with the onset of civil wars.[7] They also find that democracy does not reduce the probability of civil war onset, which they take as further support for the view that civil wars are not driven by political grievances, and finally find that civil wars in Africa have the same determinants as elsewhere in the world.

Elbadawi and Sambanis (2000, 2002) study the incidence (prevalence) of civil war, defined as "the probability of observing either a new war onset or the continuation of an ongoing war or both."[8] The confirm most of Collier and Hoeffler's findings on the role of economic factors, but also find that ethnic fractionalization has a quadratic relationship with the incidence of civil war, with the highest probability of civil war at intermediate levels of diversity. In another departure from Collier and Hoeffler, they find that democracy reduces the incidence of civil war, including in Africa.

Like the above scholars Fearon and Laitin (2003) also find that lower per capita GDP is significantly associated with the onset of a civil war, and this appears to be the most robust finding of the existing literature. However, unlike Collier and Hoeffler, Fearon and Laitin argue that the key channels linking poverty and civil war include a weak state military and poor roads: to the extent that faster

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[6] Sambanis 2001.
[7] Collier and Hoeffler 1998, 2000, 2001, 2002.
[8] Elbadawi and Sambanis 2002, 307.

economic growth leads to more government revenue, it could also strengthen the state's military and institutional capacity to combat insurgencies, further discouraging civil conflict. Using novel geographic data, they also emphasize the role played by rough terrain (captured by percentage of the country that is mountainous) in sustaining rebellions empirically.

These authors are well aware of the potential endogeneity problem in estimating the relationship between civil wars and the economic variables, and they attempt to address this by using lagged values of GDP and/or GDP growth as explanatory variables. However, this approach is prone to omitted variable bias: wealthier countries differ from poor countries along many dimensions, some of which are difficult to measure, and thus it is difficult to pin point the true underlying causes of civil conflict. The existing studies also implicitly assume that economic actors do not anticipate the incidence of civil war, and adjust economic activity (e.g., investment) accordingly. Below we adopt a different approach.

3. Data and Measurement

3.1 Data on Civil Conflict

We use the new Armed Conflict Data database developed by the Peace Research Institute of Oslo (PRIO) and the University of Uppsala, Sweden (we refer to it as the PRIO database, for simplicity). Hitherto most contributors to the literature have worked with, or built on, the Correlates of War (COW) database. However, the lack of transparency and the many inconsistencies of the COW database when it comes to civil wars are well known to researchers, and have been the subject of a detailed evaluation by Sambanis.[9] While other less problematic databases exist – such as those developed by Fearon and Laitin and by the World Bank – all of these alternatives continue to adhere to the precedent established by COW of using a death threshold of 1000 battle deaths to identify civil wars. The consequence is that they miss many important civil conflicts with fewer than 1000 deaths per year, conflicts that may be particularly significant in countries with small populations, of which there are many in Sub-Saharan Africa.

[9] Sambanis 2002. For instance, it is not clear if COW uses 1000 cumulative deaths, or 1000 deaths per year when identifying a civil war.

The PRIO database is more transparent in its construction than COW, avoids some of the ambiguities of other databases, and also, uniquely, records all conflicts with a threshold of only 25 battle deaths per year, far lower than the existing databases. In the PRIO database an armed conflict is defined as follows. "An *armed conflict* is a contested incompatibility which concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths."[10] While the PRIO database also includes information on interstate conflict, we focus exclusively on the categories of conflict which are classified as civil wars – their Categories 3 and 4, which cover intrastate conflict with and without interference from other countries, respectively. All country-year observations with a civil conflict in progress with at least 25 battle deaths per year are coded as ones, while other observations are zeros; the civil conflict indicator variable for country *i* in year *t* is denoted $CONFLICT_{it}$. Appendix Table 1 contains a list of all countries in our sample, and the years for which they are coded as having a conflict in both the PRIO and Fearon and Laitin datasets. As is well-known, the descriptive statistics indicate that civil conflict was remarkably widespread in sub-Saharan Africa during the period 1983-1999: fully 28 percent of all country-year observations suffered from civil conflict according to the PRIO definition, and 26 percent under the Fearon and Laitin definition (Table 1, Panel A).

Some examples illustrate the strengths of the PRIO database. The Fearon and Laitin dataset indicates that there was no civil conflict in Niger during 1990 to 1997 using the 1000 deaths threshold, whereas the PRIO dataset codes civil conflict in Niger for 1990-2, 1994, and 1996-7. The PRIO dataset also appears more sensitive to temporary breaks in conflict than the other datasets: while the Fearon and Laitin dataset indicates there was continual civil conflict in Senegal from 1989-1999, the PRIO dataset codes conflict in Senegal in 1990, 1992-3, 1995, and 1997-9.

3.2 Weather Data

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[10] Refer to the University of Uppsala website (www.peace.uu.se) or the PRIO website (www.prio.no).
[11] University of Uppsala website (www.peace.uu.se).

We employ satellite imagery on vegetation levels – the normalized difference vegetation index (NDVI) – as a source of information on weather variability.[12] As Karabalut concisely describes it, “the NDVI approach is based on the fact that healthy vegetation has a low reflectance in the visible [red] portion of the electromagnetic spectrum due to chlorophyll and other pigment absorption and has high reflectance in the near infrared [NIR] portion because of the internal reflectance of the mesophyll spongy tissue of the green leaf. … NDVI is related to the absorption of photosynthetically active radiation and basically measures the photosynthetic capacity of leaves.”[13]

NDVI is closely correlated with rainfall: “comparative data show that there is a near linear relationship between NDVI and precipitation in a range of semi-arid lands of Africa” (Anyamba et al 2002: 138), with a correlation of approximately 0.9 across a variety of climatic regions and vegetation types in Sub-Saharan Africa (Nicholson et al 1990). The strong correlation between rainfall and NDVI has been confirmed in separate studies in regions ranging from extremely arid North Eastern Nigeria, and semi-arid South Western Iran, to the mixed grasslands and pinelands of the Great Plains and the Black Hills in South Dakota, to the rainforests of the Amazon basin.[14]

A strong correlation with rainfall does not, however, suffice to establish that our instrument is exogenous to civil wars. This is so because wars could plausibly make it difficult to plant crops at all, or could at least force shifts in cropping patterns. However, there is no evidence of a relationship between the presence of specific crops and NDVI, even at extremely high resolution: given the logic of NDVI described above, being essentially a rough measure of photosynthetic activity rather than images of crops themselves, it is unsurprising that geographers have been unable to find a relationship between the presence of “bush” versus cultivated land in the spectral reflections that are captured in NDVI.

[12] NDVI is derived from data collected by National Oceanic and Atmospheric Administration (NOAA) satellites, and processed by the Global Inventory Monitoring and Modeling Studies (GIMMS) at the National Aeronautics and Space Administration (NASA). NDVI is calculated from two channels of the AVHRR sensor, i.e., reflected solar radiation in the near-infrared (NIR) and visible (VIS) wavelengths, using the following formula: NDVI = (NIR - VIS)/(NIR + VIS). Characteristics of these NDVI data include: spatial resolution of 8.0 km; Albers equal area (conic) projection; calibration for inter- and intra-sensor degradation; and calibration for El Chichon and Mt. Pinatubo volcanic events. For more information: http://www.fews.net/current/imagery/index.cfm.

[13] Karabalut 2002, 94.

[14] Refer to Hess et al. 1996, Damizadeh et al. 2001, Karabulut 2002, and Singer and Caldas de Castro 2001.

As far as our use of NDVI is concerned, we collected NDVI measures for each point at which the latitude and longitude degree lines cross, in order to collect information in a geographically uniform fashion throughout all African countries.[15] Thus, a medium-sized country like Kenya contains 50 degree "nodes", while smaller Malawi contains nine nodes. In this sense the satellite vegetation data has numerous advantages over direct rainfall reports. Although there are some time series data for rainfall in Africa (refer to FAO 2001), there are typically few rainfall stations per country (some countries, like Angola are missing entirely from the data) that are not uniformly spread throughout the country; there are many gaps in the data (missing years); the rainfall measures are of unknown reliability, and weather stations may cease to operate in times of budget crisis or armed conflict.

The NDVI measure at latitude-longitude degree "node" point p in country i during year t is denoted V_{ipt}, and we consider the average vegetation across all points p for that year, V_{it}. The principal measure of a weather shock is the change in vegetation from the previous year, ΔV_{it}, which we find below is strongly correlated with economic growth. Positive values typically denote improved rainfall, since most of sub-Saharan Africa lies within the semi-arid tropics and is thus prone to drought. Descriptive statistics indicate that there is considerable variation in vegetation across years in the sample from 1983 to 1999 (Table1, Panel B). To validate the accuracy of the vegetation measures in capturing rainfall variation, however, we matched up each rainfall station in the FAO series to our nearest NDVI node, and found a striking correlation of 0.79 between the two series, further evidence on the strong relationship between rainfall and vegetation across sub-Saharan Africa.[16]

3.3 Other Country Characteristics

The remaining cross-country data is drawn from Fearon and Laitin (2003), and from the World Bank.[17] These variables include: ethnolinguistic fractionalization (drawn from a Soviet ethnographic index), and

[15] We could conceivably collect essentially a continuum of such points, but this would massively increase data construction and processing costs.
[16] Rainfall stations within 0.15 latitude and longitude degrees of the NDVI measure point were used.
[17] We thank for Fearon and Laitin for their generosity with this data.

religious fractionalization, based on the CIA Factbook; measures of democracy from the Polity IV data set; log of per capita income (from the Penn World Tables and the World Bank); the proportion of a country that is mountainous according to the geographer A.J. Gerard; new states (defined as countries in their first two years of independence); political instability (defined as a change of at least three in the Polity IV Index in any of the three years prior to the country-year in question); log of total country population (based on World Bank data); oil exporters (an indicator for countries where oil constitutes more than one-third of export revenues, based on World Bank data); and military and road infrastructure measures (from the World Bank). We do not describe these well-known variables in detail here, and instead refer the reader to the excellent data description in Fearon and Laitin (2003).

4. Estimation Framework

We focus on the incidence of civil war in country *i*, year *t* ($CONFLICT_{it}$), according to the PRIO database. We use weather variation, as captured in changes in satellite vegetation measures (ΔV_{it}) as an instrumental variable for per capita economic growth ($GROWTH_{it}$) in the first stage equation, controlling for other country characteristics. Results are nearly identical if current and lagged deviations from average country vegetation are used as the instrumental variables for growth instead (results not shown). We also include country fixed effects (α_i) in some specifications to capture time-invariant country-characteristics that may be related to civil conflict and growth, including the natural resource endowments that Collier and Hoeffler examine (subscripts numbers denote the equation):

(1)
$$GROWTH_{it} = a_{1i} + X'_{it}b_1 + c_1(\Delta V_{it}) + e_{1it}$$

e is a disturbance term. Note that the first-stage relationship between vegetation and income growth is extremely strong in this sample: current and lagged vegetation deviations (Table 2, regression 1), and changes in vegetation (regression 2, point estimate 0.30, standard error 0.08) are both significantly related to income growth at over 99 percent confidence, and this strong positive relationship between rainfall and income growth is robust to the inclusion of country controls (regression 3) and country fixed effects (regression 4). The strong positive first-stage relationship is presented graphically in Figure 1, using a non-parametric Fan local regression method (with an Epanechnikov kernel, as described in Deaton 1997).

The second stage equation estimates the impact of income growth on the incidence of violence (presented here as a linear equation, although we perform both probit and linear estimation below):

(2) $$CONFLICT_{it} = \alpha_{2i} + X'_{it}\beta_2 + \gamma_2 GROWTH_{it} + \varepsilon_{2it}$$

We perform both linear Instrumental Variable Two-Stage Least Squares (IV-2SLS) estimation (following Angrist and Kreuger 2001), and a non-linear two-stage procedure following Achen (1986) to correct standard errors in the presence of a dichotomous dependent variable in the second stage. The 2SLS method is typically preferred even in cases where the dependent variable is dichotomous (Angrist and Kreuger 2001, Wooldridge 2002) since strong specification assumptions are required to justify the Achen (1986) and related Rivers and Vuong (1988) method, but we present both for completeness and find similar results with all specifications.

There are several potential concerns with our identification strategy. The first is the exclusion restriction: our strategy is valid as long as weather shocks only affect civil conflict via GDP growth, and not through some other channel. One possibility might be that high levels of rainfall leads to flooded roads and thus makes it more costly for government troops to contain guerillas. However this does not appear to be a serious threat to our strategy since higher levels of rainfall are associated with significantly *less* conflict in the reduced-form regression (Table 2, regression 5), with a point estimate of –0.61 (standard error 0.23), and thus to the extent that the hypothesized bias exists, it would imply that our estimates are bounds on the true impacts of income shocks on conflict. This negative relationship is presented graphically in Figure 2 in another non-parametric Fan regression. A potentially more serious concern is the possibility of endogeneity, for instance, that economic growth affects the vegetation measures by impacting cropping choices. However, as we discuss above, rainfall affects satellite vegetation measures in a broadly similar way for different types of plants (say, maize versus shrub) and across a range of climatic zones.

5. Main Empirical Results

The contemporaneous economic growth rate is strongly negatively correlated with civil conflict in Probit (Table 3, regression 1) and OLS specifications (regression 2) with country controls, and in a specification with country fixed effects (regression 3). Note that of the other variables prominently cited in the existing civil wars literature, mountainous countries have somewhat higher likelihood of conflict in this sample (although the effect is only marginally significant), and national population is also positively and marginally significantly associated with conflict, while the other measures are not strongly associated with conflict. We also concur with Fearon and Laitin that ethnic diversity is not significantly associated with conflict, however, unlike Fearon and Laitin, we are not vulnerable to the criticism that ethnic diversity contributes to poverty, which in turn contributes to civil conflict: ethnic diversity cannot be the root cause of the weather shocks that drive our results.

The instrumental variable estimate, including country controls, yields a point estimate of –2.31 (standard error 0.98, Table 3, regression 4), and the IV fixed effects estimate is similarly large and negative, at –2.00 (standard error 0.96, regression 5). The results in regression 5 are robust to dropping one country at a time, with coefficients ranging from –2.4 to –1.7 and remaining at 94 percent confidence levels in all regressions (results not shown). In the two-stage instrumental variable estimation with Probit estimation in the second stage (using Achen's (1986) standard error correction) the coefficient is even higher, at –2.68, though not statistically significant at traditional confidence levels. Since we have instrumented for economic growth, we make the causal assertion that the incidence of civil wars in Africa is significantly influenced by negative economic shocks, while a range of other country political, social, and geographic variables have at best a tenuous impact on the incidence of civil war in sub-Saharan Africa.

As to the size of the impact, the results indicate that it is huge: focusing on the fixed effects IV-2SLS specification as a benchmark, the point estimate indicates that a one percentage point decline in GDP increases the likelihood of civil conflict by two percentage points, and a 5 percentage point decline in growth leads to a 10 percentage point increase in the likelihood of a civil war, an increase of more than one-third of the average likelihood of conflict (note from Table 1 that the mean of the civil conflict indicator in the PRIO database is 0.28). Attenuation bias due to measurement error in the per capita income growth measures is likely to account for some of the difference between the OLS and instrumental variable estimates in Table 3, since African national accounts figures are widely thought to be recorded with considerable error.

We next explore a range of different specifications and dependent variables. In our preferred fixed effects IV-2SLS framework, the impact of economic growth on *major* civil conflicts – those with at least 1000 deaths, according to the PRIO dataset – is even larger than the impact on all conflicts, with a point estimate of –2.17 (standard error 0.82, Appendix Table A2, regression 1). Given that the mean incidence of major wars is only 0.17, a negative economic growth shock of 5 percentage points increases the likelihood of major civil war by more than one-half, a truly massive effect. In brief, by addressing the endogeneity problem, we have discovered that negative economic shocks have an even more dramatic impact on the incidence of civil war than has been previously recognized. However, note that while the point estimates on economic growth are negative and large for the PRIO database these coefficient estimates are not significantly different than zero at traditional confidence levels when we consider the Fearon and Laitin conflict indicator as the dependent variable (regression 2); this difference is due to the differences in coding of conflicts briefly described above, and exhaustively examined by Sambanis (2002b). Thus, on a cautionary note, the results are subject to an important qualification: although our findings are robust across multiple specifications for the new and transparent PRIO data base, the results are weaker when we use other databases. Given that there is no clear consensus among scholars of civil wars that one database is superior to all others, our results must thus be accepted with some caution.

Nonetheless, the lower threshold for inclusion in the PRIO database, and its greater sensitivity to year on year changes in the intensity of civil conflicts makes it particularly well-suited for the current study of short-term economic shocks and conflict in Africa

Our instrumental variable estimation strategy is ill-suited to examining the impact of income *levels* on conflict, but we do examine the effect of income growth and levels jointly in a non-instrumental variable specification, and find that the negative relationship between income growth and conflict is robust to the inclusion of lagged income levels, and that levels are not significantly associated with conflict (Appendix Table A2, regression 3). We have also conducted an OLS regression (with country fixed effects) including lagged economic growth and find that it is contemporaneous income shocks, rather than lags, that most strongly affect the likelihood of conflict (regression 4). We obtain a similar result in an IV specification (although coefficient estimates are less precise, results not shown).

The impact of economic growth shocks on the incidence of conflict is remarkably similar for African countries with a range of characteristics. Most notably, we find that the interaction between economic growth and initial per capita income levels in 1982 (Table 4, regression 1), and with two distinct measures of democracy, one continuous (regression 2) and one an indicator variable (regression 3), are not significantly related to civil conflict. Thus relatively poor (democratic) African countries hit by negative income shocks are just as prone to civil conflict as relatively rich (non-democratic) African regimes. However, the relatively limited variation in these characteristics across African countries – most African countries are both poor and undemocratic – means that these findings may not generalize to other regions, with broadly different income and political characteristics. We also find that there is no differential impact of economic growth shocks in ethnically or religiously diverse countries (regression 4), in oil-producing countries (regression 5), or in mountainous countries (regression 6).

The main IV estimates above indicate that negative income shocks are associated with greater incidence of civil conflict, but do not on their own illuminate the precise causal channels linking growth shocks to violence, and in particular the respective roles played by economic opportunities on the one hand, and the strength of state administration, military, and infrastructure on the other. Nonetheless, we feel that our results – and especially the finding that contemporaneous income shocks lead to more conflict – inherently resonate with the former: large economic shocks lead to immediate changes in individual labor market opportunities, while the strength of government institutions is likely to evolve more gradually. To explore this issue further, we directly examine some of the mechanisms highlighted by Fearon and Laitin (2003) – current military expenditures, military personnel, and extent of the road network – and find that none is significantly associated with economic growth in the IV framework (Table 5). Nor do we find that economic growth shocks lead to changes in the level of democracy (results not shown), further evidence that government institutional characteristics typically evolve gradually in the aftermath of economic shocks. (Although note that we cannot rule out that income *levels* do in fact affect military expenditures and infrastructure and contribute to the results found by Fearon and Laitin.)

6. Conclusion

Aside from contributing to the civil wars literature, we have attempted to contribute to the broader cross-country empirical literature by identifying an instrumental variable for economic growth – weather shocks – which could be used for analyses of a range of political economy issues.[18] In this paper we in particular address a significant methodological problem that lies at the core of the cross-country empirical literature on violence and civil wars, the potential endogeneity of the economic variables. We have found that negative economic growth shocks have a dramatic causal impact on the likelihood of civil war: a five percentage negative growth shock raises the likelihood of a civil war by over one-third, and the likelihood

[18] This paper constitutes a starting point for further empirical work on African political economy issues. We are already in the early stages of our second project in this area of banking crises. The majority of the countries in sub-Saharan Africa have suffered banking crises in the past two decades. By disrupting the intermediation of funds in the economy, and by imposing heavy bank restructuring expenses on governments, sometimes amounting to over a quarter of GDP, these crises have imposed a heavy financial burden on affected countries. Systematic study of the incidence and duration of banking crises in Africa has been afflicted by endogeneity problems much like the ones addressed in this paper; whereas slower growth contributes to the incidence and duration of banking crises, banking crises contribute to slower growth.

of a major civil war (at least 1000 battle deaths per year) by over one-half. Finally, we have found some novel evidence that the relationship between economic growth and civil war is unlikely to be due to short-run changes in the institutional or infrastructure conditions that promote insurgency. The implications of our research are potentially significant from a policy perspective: if a short-term drop in the opportunity cost of being a guerilla significantly increases the incidence of civil conflict, it may be possible to reduce the incidence of conflict through income insurance schemes for unemployed young men during hard economic times, although extensive income insurance program are likely to be difficult to fund and manage in poor and largely rural African settings.

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8. Tables and Figures

Table 1: Descriptive Statistics

	Mean	Std dev.	Obs.
Panel A: Measures of Civil Conflict (1983-1999)			
Civil conflict with ≥ 25 deaths, PRIO	0.28	0.45	647
Civil conflict with ≥ 1000 deaths, PRIO	0.17	0.38	647
Civil conflict with ≥ 1000 deaths, Collier and Hoeffler (CH)	0.17	0.38	647
Civil conflict with ≥ 1000 deaths, Doyle and Sambanis (DS)	0.23	0.42	630
Civil conflict with ≥ 1000 deaths, Fearon and Laitin (FL)	0.26	0.44	647
Panel B: Vegetation and weather measures (1983-1999)			
(Vegetation, time t) – (Vegetation, time t-1)	21.0	308.0	647
Deviation from annual average vegetation, time t	8.6	278.2	647
Panel C: Economic data			
Annual economic growth rate (t – t-1)	-0.006	0.065	647
Log(GDP per capita), time t-1	1.05	0.82	647
Panel D: Country characteristics			
Democracy level (Polity IV score), time t-1	-3.6	5.5	647
Democracy indicator (Polity IV score > 5), time t-1	0.14	0.35	647
Ethno-linguistic fractionalization (source: Atlas Marodov Mira)	0.65	0.24	647
Religious fractionalization (source: CIA Factbook)	0.49	0.18	647
Oil exporting country (source: World Development Indicators, WDI)	0.12	0.32	647
Log(mountainous) (source: Fearon and Laitin)	1.6	1.4	647
Log (national population), time t-1 (source: WDI)	8.8	1.2	647
Food aid (grain) in metric tons (source: U.N. FAO)	83304	163354	590
Military expenditures, % of central government expenditure (source: WDI)	12.2	10.0	369
Total military personnel (source: WDI)	28747	36724	411
Total road network, in km (source: WDI)	130.7	78.1	338

Table 1 Notes:
1) The vegetation measures are divided by 1000 in all regressions, to ease interpretation of the coefficient estimate. The source of the economic characteristics in Panel C is the World Bank's World Development Indicators.

Table 2: Vegetation Deviations and Economic Growth (First-Stage and Reduced-Form)

	Dependent variable:					
	Annual economic growth rate (t – t-1)				Civil conflict ≥ 25 deaths, PRIO	Civil conflict ≥ 1000 deaths, PRIO
	OLS	OLS	OLS	OLS	OLS	OLS
Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
Deviation from annual average vegetation, time t	0.31*** (0.10)					
Deviation from annual average vegetation, time t-1	-0.29*** (0.10)					
(Vegetation, time t) – (Vegetation, time t-1)		0.30*** (0.08)	0.31*** (0.08)	0.32*** (0.08)	-0.66*** (0.24)	-0.69*** (0.24)
Democracy (Polity IV), time t-1			-0.0003 (0.0006)			
Ethno-linguistic fractionalization			0.0007 (0.0113)			
Religious fractionalization			-0.007 (0.013)			
Oil exporting country			-0.013*** (0.005)			
Log(mountainous)			0.0005 (0.0020)			
Log (national population), time t-1			-0.0012 (0.0022)			
Country fixed effects	No	No	No	Yes	Yes	Yes
R^2	0.03	0.03	0.04	0.09	0.55	0.49
Root MSE	0.064	0.064	0.064	0.064	0.31	0.28
Number of observations	647	647	647	647	647	647

Table 2 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the country level. A year time trend is included in all specifications (coefficient estimates not reported). Regressions 1-4 are first-stage specifications; regressions 5 and 6 are the reduced-form specifications.

Table 3: Economic Growth and Civil Conflict

	Dependent variable: Civil conflict ≥ 25 deaths, PRIO					Civil conflict ≥ 1000 deaths, PRIO
	Probit (marginal)	OLS	OLS	IV-2SLS	IV-2SLS	IV-2SLS
Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
Annual economic growth rate (t – t-1)	-0.65** (0.28)	-0.58** (0.28)	-0.48* (0.25)	-2.27** (0.98)	-2.08** (0.96)	-2.17*** (0.78)
Democracy (Polity IV), time t-1	-0.005 (0.006)	-0.003 (0.005)		-0.003 (0.005)		
Ethno-linguistic fractionalization	0.22 (0.26)	0.21 (0.27)		0.21 (0.27)		
Religious fractionalization	-0.31 (0.26)	-0.26 (0.24)		-0.27 (0.24)		
Oil exporting country	-0.01 (0.20)	0.01 (0.19)		-0.01 (0.20)		
Log(mountainous)	0.080** (0.043)	0.074* (0.040)		0.075* (0.039)		
Log (national population), time t-1	0.082 (0.052)	0.073 (0.048)		0.71 (0.49)		
Country fixed effects	No	No	Yes	No	Yes	Yes
R^2	-	0.11	0.55	-	-	-
Root MSE	-	0.43	0.31	0.44	0.33	0.30
Number of observations	647	647	647	647	647	647

Table 3 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the country level. The IV for annual economic growth in (4) and (5) is {(Vegetation, time t) – (Vegetation, time t-1)}. A year time trend is included in all specifications (coefficient estimates not reported).

Table 4: Interactions between Economic Growth and Country Characteristics

Explanatory variable	Dependent variable: Civil conflict ≥ 25 deaths, PRIO IV-2SLS (1)	IV-2SLS (2)	IV-2SLS (3)	IV-2SLS (4)	IV-2SLS (5)	IV-2SLS (6)
Annual economic growth rate (t – t-1)	-1.00 (1.52)	-2.25** (0.89)	-2.63** (1.17)	-5.7 (4.8)	-2.17** (0.99)	-2.95* (1.62)
Economic growth rate * Log (Per capita income, 1982)	-1.32 (1.52)					
Economic growth rate * Democracy (Polity IV score), time t-1		0.01 (0.14)				
Economic growth rate * Democracy (Polity IV score >5), time t-1			1.8 (1.6)			
Economic growth rate * Ethno-linguistic fractionalization				-6.9 (4.9)		
Economic growth rate * Religious fractionalization				14.8 (11.7)		
Economic growth rate * Oil exporting country					-2.7 (8.7)	
Economic growth rate * Log(mountainous)						0.39 (0.57)
Country controls	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	No	No	No	No	No	No
R^2	-	-	-	-	-	-
Root MSE	0.45	0.44	0.44	0.47	0.45	0.44
Number of observations	646	647	647	647	647	647

Table 4 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the country level. The IV for annual economic growth and the interaction term are {(Vegetation, time t) – (Vegetation, time t-1)} and {(Vegetation, time t) – (Vegetation, time t-1)} interacted with the appropriate covariate. A year time trend is included in all specifications (coefficient estimates not reported). The country controls are those included in Tables 2 and 3 above: Democracy (Polity IV), time t-1; Ethno-linguistic fractionalization; Religious fractionalization; Oil producing country; Log(mountainous); Log (national population), time t-1. Similar interaction results hold in most OLS specifications (results not shown). Initial income is also included as a control in regression 1; initial log per capita income for Namibia is for 1990, the first year it is in the sample.

Table 5: Channels linking Economic Growth to Civil Conflict

	Dependent variable:			
	Receipt of food aid (grains), metric tons	Military expenditures	Military personnel	Total road network (km)
	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS
Explanatory variable	(1)	(2)	(3)	(4)
Annual economic growth rate (t – t-1)	-12596** (5867)	-21.1 (16.8)	-41542 (47489)	128.7 (93.4)
Country fixed effects	Yes	Yes	Yes	Yes
R^2	-	-	-	-
Root MSE	13.0	4.6	14247	38.1
Number of observations	590	369	411	338

Table 5 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the country level. The IV for annual economic growth is {(Vegetation, time t) – (Vegetation, time t-1)}. A year time trend is included in all specifications (coefficient estimates not reported). The change in sample size is due to the fact that these data series only run from 1989-1999, and there is also considerable missing data for many country-years after 1989. The coefficient estimate in (1) is divided by 100 for ease of presentation.

Figure 1: Non-Parametric First-Stage Fan Regression (Epanechnikov Kernel), Economic Growth Rate on Changes in Vegetation (conditional on country fixed effects)

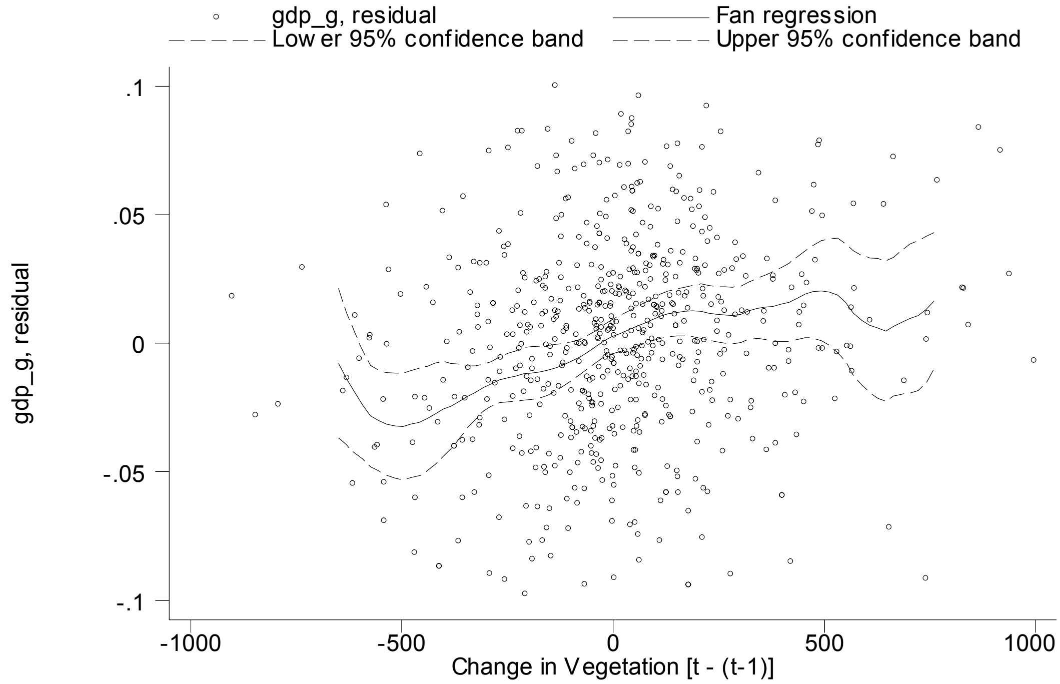
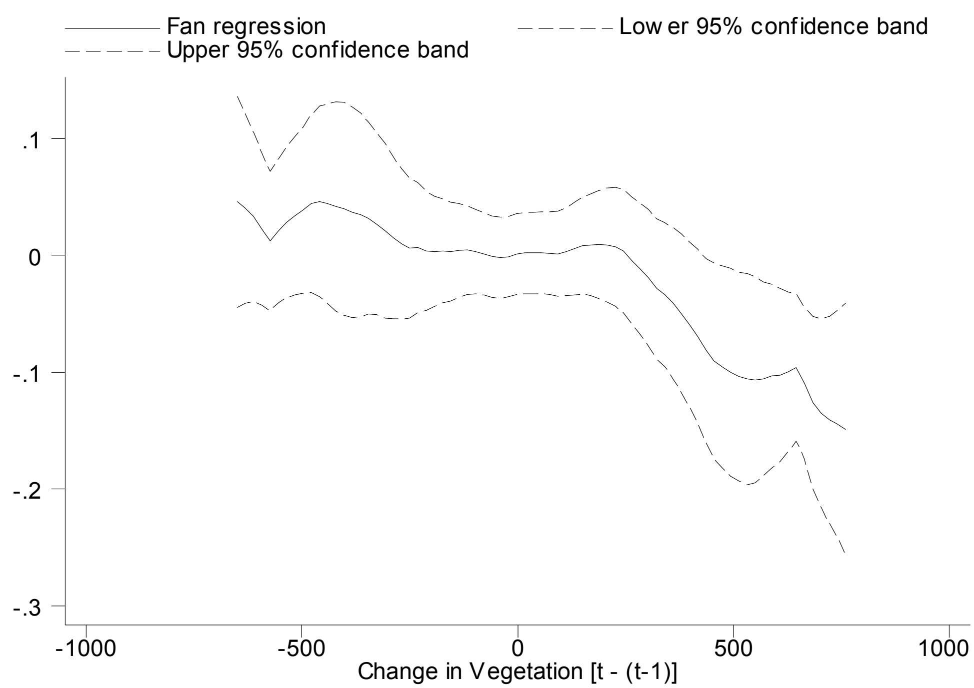


Figure 2: Non-Parametric Reduced-form Fan Regression (Epanechnikov Kernel), Likelihood of Civil Conflict (≥ 25 battle deaths, PRIO) on Changes in Vegetation (conditional on country fixed effects)



9. Appendix

Appendix Table A1: List of countries in the sample

Country	Total Years	Years of Civil conflict ≥ 25 deaths, PRIO	Years of Civil conflict ≥ 1000 deaths, PRIO
1. Angola	17	17	15
2. Benin	17	0	0
3. Botswana	17	0	0
4. Burkina Faso	17	3	1
5. Burundi	17	8	1
6. Cameroon	17	1	0
7. Central African Republic	17	0	0
8. Chad	17	15	9
9. Republic of Congo (Brazzaville)	17	3	3
10. Democratic Republic of Congo (Kinshasa)	16	10	9
11. Cote D'Ivoire	17	0	0
12. Djibouti	9	1	0
13. Ethiopia	17	13	9
14. Gabon	17	0	0
15. Ghana	17	1	0
16. Guinea	17	2	1
17. Guinea-Bissau	17	2	1
18. Kenya	17	0	0
19. Lesotho	17	1	0
20. Liberia	9	3	1
21. Madagascar	17	0	0
22. Malawi	17	0	0
23. Mali	17	2	0
24. Mauritania	17	0	0
25. Mozambique	17	10	10
26. Namibia	10	2	2
27. Niger	17	6	0
28. Nigeria	17	0	0
29. Rwanda	17	9	5
30. Senegal	17	7	1
31. Sierra Leone	17	9	2
32. Somalia	9	9	3
33. South Africa	17	11	11
34. Sudan	16	16	14
35. Swaziland	17	0	0
36. Tanzania	17	0	0
37. Togo	17	2	0
38. Uganda	17	15	10
39. Zambia	17	0	0
40. Zimbabwe	17	2	2
TOTAL	647	180	110

Table A1 Notes: Eritrea, Equatorial Guinea, and the Gambia were dropped from the analysis due to missing data.

Appendix Table A2: Results using Other Measures of Civil Conflict

	Dependent variable:				
	Civil conflict ≥ 25 deaths, PRIO	Civil conflict ≥ 1000 deaths, PRIO	Civil conflict ≥ 1000 deaths, CH	Civil conflict ≥ 1000 deaths, DS	Civil conflict ≥ 1000 deaths, FL
	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS
Explanatory variable	(1)	(2)	(3)	(4)	(5)
Annual economic growth rate (t – t-1)	-2.08**	-2.17**	-1.67*	-1.56*	-0.87
	(0.96)	(0.78)	(0.85)	(0.92)	(0.75)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	-	-	-	-	-
Root MSE	0.33	0.30	0.25	0.30	0.27
Number of observations	647	647	647	630	647

Table A2 Notes:
1) Huber robust standard errors in parentheses. Significantly different than zero at 90% (*), 95% (**), 99% (***) confidence. Regression disturbance terms are clustered at the country level. The IV for annual economic growth is {(Vegetation, time t) – (Vegetation, time t-1)}. A year time trend is included in all specifications (coefficient estimates not reported).