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Civil Wars and Economic Growth in Sub-Saharan Africa[1]

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This paper uses panel data from a sample of Sub-Saharan African (SSA) countries over the 1960–96 period and both Instrumental Variables (IV) and dynamic panel data (DPD98) estimator to investigate the effect of the incidence and severity of civil war on the growth rate of per capita income. We find that both factors have a robust, negative and statistically significant effect on the growth rate of per capita income. We find that civil war affects the growth rate of income partly through reduced investment in physical capital. However, if one does not control for the correlation between civil war incidence and other growth factors, the estimated effect of civil war on economic growth is not robust. We are unable to find any significant relationship between the level of income and the incidence of civil war in SSA countries after controlling for other variables that are correlated with income levels.

1. Introduction

This paper uses panel data from a sample of Sub-Saharan African (SSA) countries during the 1960–96 period and both Instrumental Variables (IV) and Dynamic Panel Data (DPD) estimation methodologies to investigate the effects of civil war on the growth rate of per capita income. We do so by estimating a growth equation that includes the incidence and severity of civil war as additional regressors. We also investigate one of several possible mechanisms

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through which civil war incidence affects the growth rate of income as well as the effect of civil war incidence on the level of per capita income. The distinguishing feature of our study is that we instrument for the incidence of civil war to get around the possible endogeneity of civil war incidence. We employ two different measures of civil war in this study, thus increasing confidence in our results. We focus on SSA because of the combination of a large number of civil wars and poor economic performance on the continent, since decolonisation in the 1960s. In spite of the observed co-movement of civil wars and poor economic performance, studies of economic growth in SSA countries have not investigated the effects of civil war on economic growth. Most empirical growth studies have focused on the effects of other variables on economic growth in Africa, using civil war incidence only as a conditioning variable, if at all.

The economic performance of SSA over the last three decades has been abysmal, leading some observers to refer to this growth performance as a 'tragedy' (Easterly and Levine, 1997; Atardi and Sala-i-Martin, 2003). SSA is the only part of the developing world where per capita income and living standards have declined over the period. The deteriorating living standards have been accompanied by an increase in the incidence of civil wars; about 20 SSA countries have experienced at least one period of civil war since the attainment of independence in the 1960s. Indeed, some SSA countries (e.g., Angola, Mozambique, Sudan) have hardly had any period without civil war since they attained independence. Even SSA countries that were considered islands of stability in the 1970s, such as Côte d'Ivoire and Liberia, did not escape the incidence of civil wars at the turn of the twentieth century. While civil wars have declined in other parts of the world, the incidence and intensity of civil wars have increased in this region. Of the 27 active armed conflicts going on around the world in 1999, about 41% of them were civil wars taking place in SSA, a region with less than 11% of the world's population (SIPRI, 2000).[2]

Empirical research on the growth impact of civil war incidence has yielded mixed results. While some researchers find negative effects, others do not find any significant effect. Levine and Renelt (1991) find that the effect of civil war on the growth rate of per capita

[2] See SIPRI Yearbook, 2000 (Oxford).

income is not robust; the sign, magnitude and statistical significance of the civil war dummy variable changes with conditioning variables. Part of the inconclusiveness of the results may stem from the fact that some of the variables that cause civil wars, such as ethno-linguistic fractionalisation, primary commodity dependence and low stocks of human capital, are also determinants of income growth. Indeed, the economics of civil war literature suggests that the incidence of civil war is partly explained by income growth as well as variables that determine income growth, making the incidence of civil war a potentially endogenous variable in an income growth equation.

Does the incidence of civil war have any negative effect on the growth rate of per capita income in SSA countries? Is this effect independent of the underlying socio-economic factors that cause civil war? Is this effect a permanent one? These are some of the issues we investigate in this study. The 'new' growth literature suggests that state failure generally has deleterious effect on economic growth (Barro, 1991; Easterly *et al.*, 1993; Barro and Lee, 1994; Easterly and Levine, 1997; Sala-i-Martin, 1997; Gyimah-Brempong and Traynor, 1999; Murdock and Sandler, 2002). We view the incidence of civil war as a manifestation of state failure in the sense of inability to peacefully mediate and resolve conflicts. As indicated above, the economics of civil war literature suggests that civil wars have economic as well as non-economic causes and consequences. In particular, high unemployment rate, primary export dependency, low human capital stock, slow economic growth, and weak and ineffective central authority stemming from poor fiscal conditions have been suggested as possible causes of the incidence of civil war.

The findings of the two strands of research suggest the possibility that cross-country differences in the growth rate of income and the propensity for civil war are driven by common factors. For example, Nigeria and Gabon are oil exporting SSA countries with divergent growth paths. Nigeria has experienced slow income growth, civil war and political instability, while Gabon has experienced respectable income growth, no civil war and a relatively long period of what passes for political stability in SSA. Is it possible that Nigeria's slow growth is due to the high degree of ethno-linguistic and religious fractionalization, low human capital stock and weak central government that result in a high propensity for civil war?

The usual approach to investigating the impact of civil war on economic growth is to include a dummy variable for the incidence of a civil war and interpret the coefficient of this variable as the growth effect of a civil war (e.g., Barro and Sala-i-Martin, 1995). The coefficient of a civil war dummy variable cannot distinguish between the growth effects of civil war and unobserved country characteristics that explain the propensity for civil war. In the Nigeria/Gabon example, the civil war dummy cannot distinguish between the growth effects of ethnic fractionalisation, which retards economic growth and may cause civil war, and the growth effect of the occurrence of civil war itself. It is not clear whether the growth rate of Nigeria would be higher had it not actually had a civil war. It is therefore necessary to account for the possible endogeneity of civil war incidence if researchers are to properly identify the growth impact of civil war incidence.[3]

The economics of civil war literature gets around this endogeneity problem by lagging the growth rate of income in the probability of civil war equation. If, in addition to initiation, civil war is sustained by poor economic performance, then economic growth is likely to be an endogenous variable in the incidence of civil war. Moreover, as indicated above, most of the variables used to explain the incidence of civil war are themselves explanatory variables m the income growth equation. Furthermore, these variables change very slowly over time, hence they are likely to be correlated with income growth and civil war incidence with long lags. The result is that it is not easy to isolate the growth impact of civil war incidence with a simple dummy variable approach. We account for this unmeasured endogeneity of civil war incidence in our study.

Table 1 presents some comparative statistics of growth variables for a sample of SSA countries during our sample period. The data show that countries that experienced civil war during the sample period have average per capita incomes that are 50% lower than countries that experienced no civil wars. Investment/GDP ratios and stocks of education human capital in civil war countries are at least 50% lower than the average for countries that had no civil war. The civil war group of countries are also more primary export dependent, have fewer civil liberties and less effective legislatures, and experience higher rates of inflation than their counterparts with

[3] We use the term civil war incidence to refer to initiation and duration of a civil war.

Table 1: *Comparative statistics*

	No civil war		Civil war	
Variable	Mean[a]	Standard deviation	Mean	Standard deviation
ẏ	1.1604	5.2396	-0.3568	4.5167
y (*87 PPP $*)	1224.09	1004.37	786.04	292.71
govcon (%)	22.754	8.586	22.845	7.2065
k (%)	11.868	7.4881	6.3819	5.6789
edu	2.381	1.323	1.4658	0.6763
trgdp	0.0249	0.0113	0.0249	0.0114
civ	0.389	0.1862	0.1762	0.2813
legef fct	2.078	0.498	1.021	1.809
primary (%)	15.577	10.579	19.1416	11.8027
inflation rate (%)	13.4568	16.882	108.413	713.439
N	176		44	

[a] Unweighted averages.

no civil wars. The upshot is that countries that had civil war(s) have lower endowments of growth enhancing characteristics than the countries that did not have civil war. Not surprisingly, the unweighted average growth rate of per capita income in the civil war countries during the sample period was 0.36%, compared with 1.16% for the non civil war countries. Can the cross-national differences in income growth rate be explained by differences in observed 'traditional' growth factors alone? If the answer is yes, then the coefficient of the civil war variable should be zero, once a researcher accounts for all observable growth variables in a cross country growth equation.

The approach we use to overcome the endogeneity problem is as follows: we use a one-period lead of the predicted probability of civil war as an instrument for the incidence of civil war. Our rationale for using this instrument is that the probability of a civil war is a function of underlying socio-economic factors that are highly persistent over time, making current civil war propensity highly correlated with future civil war propensity, which in turn will be highly correlated with the actual incidence of civil war in

the current period. However, because the one-period lead propensity for civil war is a future value, it is not correlated with the error term of the growth equation in the current period.

Investigating the effects of civil war on economic growth in SSA is an important policy issue. If the incidence of civil war has a significantly negative impact on the growth rate of income, then efforts should be made, including the establishment of regional institutions to maintain peace, to prevent the incidence of civil wars as one way of increasing economic growth rate in SSA countries. If civil war is found to have a short-term growth effect but no long-term effect on income levels, then from an economic policy point of view, the quest to end or avoid civil wars is only based on inter-temporal substitution of current for future income growth. On the other hand, if we find that civil wars have long-term impact on the level of income, then there will be economic reasons to find an end to or to avoid civil wars. If there is no robust negative growth effect of civil war incidence, then the quest to end civil wars in SSA should be justified on moral, political and humanitarian, rather than economic grounds.

We find that civil war incidence has a negative, statistically significant and robust effect on the growth rate of per capita income in SSA. The negative growth effect is, however, robust only if we account for possible endogeneity of civil war incidence. In addition to the direct negative effect, we also find that one of the mechanisms through which civil war incidence decreases the growth rate of income is decreased investment in physical capital. We are, however, unable to find any significant effect of civil war incidence on the level of per capita income after accounting for other factors that are correlated with the level of income. We also find that the severity of civil war has a negative growth effect apart from the growth effect of civil war incidence. Our results are quite robust to the measures of civil war, the measure of income and the method of accounting for the endogeneity of civil war incidence in estimation.

The rest of the paper is organised as follows: Section 2 briefly reviews the recent empirical literature on the relationship between civil war and economic growth. Section 3 introduces the econometric model used to investigate the relationship between economic growth and civil war incidence, and discusses the estimation methodology, while Section 4 discusses the data used for the study.

Section 5 presents and discusses the statistical results and draws some policy conclusions. Section 6 concludes the paper.

2. Literature Review

The growth empirics literature has been growing exponentially during the last decade.[4] Because the literature is vast, we briefly mention only a few of the studies that include civil war as an explanatory variable. Barro and Lee (1994) and Caselli *et al.* (1996) find no significant growth impact of civil war. Easterly *et al.* (1993) find no statistically significant relationship between war casualties and growth rate. Barro (1991), Sachs and Warner (1997) and Sala-i-Martin (1997) find a significantly negative growth effect of civil war. Easterly and Levine (1997) point to ethnic conflicts, including ethnic wars, as a major source of Africa's poor economic performance. Ritsen *et al.* (2000) develop a model in which lack of social cohesion leads to conflict and war, which in turn leads to reduction in growth rates of per capita income. Rodrik (1999), although not directly addressing civil war, argues that the failure of some developing countries to recover from external shocks in the 1980s can be attributed to ethnic conflicts. The problem, he argues, is not ethnic or religious fractionalisation so much as the failure to develop institutions to mediate conflicts that arise in any society. Atardi and Sala-i-Martin (2003) conclude that civil conflict decreased the average annual growth rate of GDP in SSA by 0.5 percentage points in the second half of the twentieth century. With the exception of Atardi and Sala-i-Martin (2003), none of these studies was primarily interested in investigating the impact of civil war on income growth; they only used civil war as a conditioning variable.

Murdoch and Sandler (2002) is the first study we know of that investigates the effects of civil war on income growth. Using the augmented neoclassical growth model of Mankiw *et al.* (1992), with civil war incidence and intensity as added regressors, the paper finds that civil war incidence has a statistically significant negative impact on the levels of per capita income and substantially negative impact on the growth rates of per capita income in a country and those of neighbouring countries. The paper also finds that civil war

[4] See Temple (1999) and Durlauf and Quah (1999) for reviews of the "new" growth literature.

intensity, as measured by war deaths, affects economic growth negatively; the greater the intensity of the conflict, the greater the spatial spill-over effects. In addition, the paper finds that the impact of civil war on income is short-term in nature. We note that the paper treats civil war as an exogenous variable.

The economics of civil war literature, 'launched' by Collier and Hoeffler (1998), casts the causes of civil wars in terms of utility maximisation: rebels will initiate a civil war if the expected benefits of rebellion exceed the costs. Using civil war data during the 1960–92 period and probit and tobit analyses, they find that ethno-linguistic fractionalisation, initial income, dependence on natural resource exports and population size are strong determinants of the probability of the incidence of civil war. In subsequent work, Collier and Hoeffler (2002) and Collier (2000, 2002) expand the economic causes of civil war using both theoretical and empirical analyses of the initiation and duration of civil war. Of particular interest to our paper, they find that lagged economic growth, low income, availability of a large number of unskilled unemployed young men and primary export dependency are important economic determinants of the initiation and duration of civil wars, besides political and ethno-linguistic variables.

Elbadawi and Sambanis (2000, 2002) apply a variant of the Collier–Hoeffler model to African data. Defining the incidence of civil war as the sum of the probability of war initiation in a period given the presence of peace in the previous period and the probability of war in a period given the presence of war in the previous period, they confirm the Collier–Hoeffler thesis of civil war incidence. However, they find that lagged income growth rate is not a significant predictor of civil war incidence. Miguel *et al.* (2004) use an IV approach to investigate the effects of economic performance on the incidence of civil war in SSA countries. Using variation in rainfall as an instrument for economic growth, the paper finds that economic growth has a large, statistically significant negative impact on the probality of a civil war. Furthermore, the paper finds that once one controls for the growth of income, the probability of civil war is not influenced by other variables, such as democracy and geography, that are not important determinants of civil war incidence.

There have been some important contributions to the civil war literature by political scientists recently. Fearon (2001), using more

comprehensive civil war data, finds that once one accounts for the level of income and geography, other variables are not significant predictors of the probability of the initiation or duration of civil wars. Fearon and Laitin (2003), in a comprehensive study of the relationship between ethnicity, insurgency and civil wars, concludes that the risk of civil war in a country is influenced by poverty, political instability, rough terrain and large populations. They argue that once one accounts for these factors, ethnic or religious fractionalisation has no significant impact on the risk of civil war incidence. Dudley and Miller (1998) evaluate four theories of civil war incidence and find strong support for the economic model of civil war. The economic determinants of civil war indicates that lagged economic growth and some socio-cultural variables that determine economic growth are important determinants of the incidence of civil war, suggesting that civil war may be an endogenous variable in growth equations. The results of the civil war studies suggest that factors that lead to the initiation of civil wars are, generally, different from those that sustain civil wars.

3. Model

3.1. Growth Rate Equation

Civil war can affect economic growth through several channels. It is likely to decrease the stock of physical capital through destruction of infrastructure, as well as reduction in investment in capital as a result of capital flight, reduced savings and increased uncertainty. Increased uncertainty is also likely to decrease the inflow of foreign direct investment (FDI). In the same way, the stock of human capital can be decreased by civil war as people are killed, educated and skilled people emigrate, and fewer people are trained as resources are diverted to fight the war. A civil war, especially an ethnically based one, is likely to destroy social capital and social and political institutions that are necessary to mobilise and utilise resources for economic growth. In addition to decreased resource accumulation, civil war can directly disrupt the employment of existing resources, reduce production and hence economic growth. All these factors can also lead to decreased total factor productivity, as endogenous growth theory suggests.

We combine the insights of the growth empirics and the economics of civil war literatures in our study. Our model is

a growth equation formed from the two research literatures. Following the empirical growth literature (Romer, 1986; Barro, 1991; Barro and Lee, 1994; Jones, 1995; Caselli *et al.*, 1996; Hall and Jones, 1999), we make the growth rate of per capita income ($\dot{y}$) a function of the growth rates of technology ($\dot{a}$), per capita physical and human capital ($\dot{k}, \dot{h}$) and environmental factors, including civil wars. Because we are interested in the growth impacts of civil war, we disaggregate the vector of environmental variables into civil war (*civwar*) and all other environmental variables (**Z**). The per capita income growth function is given as:

$$\begin{aligned} \dot{y} &= \dot{y}(\dot{a}, \dot{k}, \dot{h}, civwar, \mathbf{Z}) \quad \partial y/\partial a, \partial y/\partial k, \partial y/\partial h \geq 0 \\ & \partial y/\partial civwar \leq 0 \end{aligned} \tag{1}$$

where all variables are as defined in the text above.

The specific functional form of the growth equation we estimate follows those of earlier researchers (e.g. Feder, 1983; Barro, 1991; Mankiw *et al.*, 1992; Sachs and Warner, 1997; Edwards, 1998).We write the growth rate of per capita income as a linear function of investment/GDP ratio (k), the stock of human capital (h), government consumption (*govcon*) as a proxy for economic policy, openness of the economy (*trgdp*), initial income (y_0) and *civwar*. The equation we estimate is given as:

$$\begin{aligned} \dot{y}_{it} &= \alpha_0 + \alpha_1 k_{it} + \alpha_2 edu_{it} + \alpha_3 y_{0,it} + \alpha_4 govcon_{it} + \alpha_5 trgdp_{it} \\ &+ \alpha_6 civwar_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

where *edu* is education, which we use a proxy for human capital, ε_{it} is a stochastic error term and all other variables are as defined in the text above. We expect the coefficients of k, *trgdp* and *edu* to be positive, while those of *gov* and *civwar* are expected to be negative. If conditional convergence operates in African countries, we expect the coefficient of y_0 to be negative.

3.2. Estimation Method

The growth equation is estimated with panel data from a sample of SSA countries. If there is no correlation between the error term and any of the regressors, then the Fixed Effects (FE) and the Random

Effects (RE) estimators will produce consistent estimates; otherwise they will not. Table 1 suggests that the propensity to have a civil war is correlated with some of the variables that determine the growth rate of per capita income. The correlation may be causal or it may not; both sets of variables may be influenced by a third set of factors. This situation may reflect unobserved endogeneity of the civil war variable in the growth rate equation. The possible endogeneity of *civwar* in the growth equation implies that estimating the equation directly with either as FE or RE estimator will produce biased, and possibly inconsistent, estimates. One possible way to resolve this problem is to estimate structural equations. However, because there are so many variables that affect the growth rate of countries, a structural equations model becomes very complex to estimate. In African countries, where data are sparse and have dubious quality, this could lead to estimates that are, at best, of little validity.

Alternatively, one could use an IV estimator to estimate the growth equation as in Sachs and Warner (1997) or the Dynamic Panel Data (DPD) estimator, a General Method of Moments (GMM) estimator proposed by Arellano and Bond (1991), as used by Caselli *et al.* (1996). If all regressors are strictly exogenous, the DPD, IV, FE and RE estimators will produce consistent estimates, but only estimates from the latter two are efficient. The DPD estimator uses lagged endogenous variables and current values of exogenous variables as instruments in estimation. It will produce valid and consistent estimates if and only if the error terms are not autocorrelated. We consider endogenous regressors as predetermined for $v_{i.t+2}$ but not for v_{it}, thus allowing us to use all x_t up to x_{t-1} as valid instruments $\hat{x}_{it}$. The linear moment restriction implied by the growth equation is

$$E[(\Delta\bar{y}_{it} - \Delta\tilde{X'}_{i,t-1}\Theta)X_{i,t-j}] = 0 \quad \text{for} \quad j = 2, \ldots t-1$$

where $X' = (y_{t-1}, X)$ is the vector of lagged endogenous and strictly exogenous regressors. Given our argument that the factors that determine the incidence of civil war are highly persistent over time, the lagged values of civil war incidence are likely to be correlated with the error term of the growth equation in the current period. This makes the usual DPD estimator inappropriate for our purposes. However, Arellano and Bond (1991) have developed a new version of the estimator (DPD98) that allows one to use future

values of a variable as an instrument for estimation. In addition to the IV estimator, we present estimates of the growth equation based on the DPD98 estimator. Arellano and Bond present two estimators—the one- and two-step estimators. As is the usual practice, we present the two-step estimator but base statistical inference on the one-step estimator.

The IV estimates uses the one period lead of the predicted value of the probability of civil war incidence ($pcivwar_{t+1}$) as a regressor. Because this regressor is a predicted regressor, it is not fixed but stochastic, with its own probability distribution. Failure to account for the stochastic nature of this regressor in the estimation of the covariance matrix of the second-stage estimates will result in a possibly downward bias of the estimates of the variances of α_is, thus providing us with a false sense of precision of the estimates. Murphy and Topel (1985) provide methods to estimate the variance of the second stage regression coefficients that accounts for the stochastic nature of the predicted regressors. We used the method presented in Murphy and Topel's theorem 2 to estimate the variance–covariance matrix of α_is in equation (2).[5] While this approach is not likely to affect the magnitude and sign of the estimated coefficients, it is likely to have a significant impact on hypothesis tests regarding α_is.

The instrument we use for *civwar* (*ethnwgur*) is the one-period lead of predicted probability of civil war (ethnic war) ($pciwar_{t+1}$. $pethnwgur_{t+1}$) in a period. Following the civil war literature, we make the predicted probability of civil war (*pcivwar*, *pethnwgur*) a function of civil liberties (*civ*), primary export dependency

[5] Since we cannot claim that the error terms from the two equations are independent, we used the formula based on Murphy and Topel's theorem (2) to estimate the variance–covariance matrix, Σ^*. Suppose the income growth equation is given as $\dot{y} = h(X, \alpha, g(W, \beta))$ and the probability of civil war incidence is given by $\hat{g} = g(W, \beta)$; then the variance–covariance matrix of $\hat{\alpha}$, the second-stage coefficient estimates, is given as:

$$\hat{\sum}^* = \hat{\sigma}^2 V_\alpha + V_b[CV_\beta C' - CV_\beta R' - RV_\beta C']V_b \tag{5}$$

where $\sum^*$ is the variance–covariance matrix of $\hat{\alpha}$ corrected for the stochastic regressor $pcivwar_{t+1}$, $\hat{\sigma}^2 V_\alpha$ is the uncorrected variance α, V_b is the inverse of the square of the gradient of the observation matrix with respect to pseudoregressors evaluated at the true parameter values, V_β is the variance of β from the first-stage regression, $C = n$ plim $n^{-1}\sum_{i=1}^{n} X_i^0 \varepsilon_i^2 (\partial(X_i, \alpha, W_i, \beta)/\partial\beta')$, $R = n$ plim $n^{-1}\sum_{i=1}^{n} X_i^0 \hat{\varepsilon}_i (\partial g(W_i, \beta)/\partial\beta')$ and β is the coefficient estimate from the first-stage regression.

(*primary*), legislative effectiveness (*legeffct*) and ethno-linguistic fractionalisation (*elf*). Because the instrument is a predicted value, it is highly correlated with the incidence of civil war. However, because it is the future value of the probability of the incidence of civil war, it is not correlated with the error term of the growth equation in the current period. This makes it a 'good' instrument for civil war incidence. We use a Hausman specification test to test to see if the IV and DPD98 estimates are the same as estimates using current year values to measure civil war in a FE model.

4. Data

The dependent variable in this study is the growth rate of real per capita income ($\dot{y}$). We respectively measure this variable as the annual growth rates of real per capita GDP and real per capita GNP in 1987 constant PPP dollars. The explanatory variables are the initial level of per capita income (y_0), investment/GDP ratio (k), education (*edu*), openness of the economy (*trgdp*), government consumption (*govcon*) and the incidence of civil war. y_0 is real per capita income in 1987 PPP dollars at the beginning of the period. For example, y_0 for the 1960–4 period is the per capita income for 1960. We follow earlier researchers (Barro, 1991; Levine and Renelt, 1991; Barro and Lee, 1996; Sachs and Warner, 1997) and measure k as the investment/GDP ratio, while *govcon* is government consumption/GDP ratio. We measure *edu* as the average years of education attained by the population that is 25 years or older in a country, and *trgdp* as the ratio of total trade (*exports* + *imports*) to GDP. *legeffct* is a measure of the effectiveness of a country's legislature while *elf* is the probability that two randomly selected individuals in a country belong to different ethnic groups. *civ* is Gastil's civil liberties index as transformed by Barro into a 1–0 scale. It is measured as: $civ = (7 - civilliberty)/6$.*primary* is the primary commodity exports/GDP ratio.

The variable of major interest in this study is the incidence of civil war. It is hard to measure what constitutes a civil war since several different conflicts could conceivably be classified thus. Yet a distinction between major armed conflicts involving the central government and an organised army and a minor conflict that involves few people over a relatively short period of time has to be

made because they have different economic growth rate implications. Because our concern is with the growth impact of civil war, we focus on major conflicts. We admit that the criteria for determining what constitutes a major conflict is bound to be an arbitrary one.

We adopt Elbadawi and Sambanis's (2000, 2002) definition of civil war incidence in this study. The incidence of civil war in any period is the sum of two probabilities; the probability that a civil war starts in a period given that there was no civil war at the beginning of the period and the probability of observing a civil war in a period given that there was a war in the previous period. This definition of civil war incidence therefore encompasses the onset as well as the duration of the civil war. Several studies indicate that the causes of civil war initiation and duration are different (see, e.g., Feron, 2001). Measuring civil war incidence as the combination of initiation and duration may be problematic if we were interested in the causes of civil war. However, this paper is concerned with the effects of civil war incidence (both initiation and duration) on economic growth. For the purposes of this paper, therefore; not making the distinction between initiation and duration of civil war should not adversely affect our central analysis. Our definition of civil war incidence, however, does not allow for the severity of civil war. It treats a civil war with 100 casualties annually the same as one with 10,000 casualties annually. We believe that the intensity of a civil war will have an impact on the growth rate of an economy quite apart from the growth effect of the incidence. We therefore estimate the effects of the severity and the incidence of civil war separately.

We use two different measures, *civwar* and *ethnwgur*, to measure the incidence of civil war. *civwar* is derived from Singer's *Correlates of War Project* (Singer). Singer defines an armed conflict as a civil war if it meets four criteria: (i) major battle ensued entirely within the borders of a country: (ii) the government is a major combatant; (iii) effective resistance occurred on both sides; and (iv) at least 1,000 fatalities occurred during the course of the war. There were a total of 13 countries that had civil wars in at least one year during the sample period.[6] *ethnwgur* is derived from Gurr's *Minorities at Risk Project* (Gurr) and is defined as episodes of violent conflict between the national government and national, ethnic, religious or other

[6] The civil war countries are Angola, Burundi, Chad, Ethiopia, Mozambique, Nigeria, Rwanda, Sierra Leone, Somalia, Sudan, Uganda, Zaire and Zimbabwe.

communal groups which seek major changes in their status through armed conflict. To be classified as *ethnwgur*, each side must mobilise and field at least 1,000 combatants and must have at least 100 war fatalities annually. Acts unrelated to war, such as government sponsored mass murders and communal violence do not qualify as *ethnwgur.* The fatality threshold is lower for *ethnwgur* than for *civwar.* Fourteen countries had at least one incident of *ethnwgur* during the sample period.[7]

The data used in this study were obtained from a variety of sources. Data on y_0, $\dot{y}$, k, *trgdp*, and *gov* were obtained from the World Bank (2000). Data for *elf*, *legef fct*, and *civ* were obtained from R. Bates' African Research Project at Harvard University. The data were downloaded from the project's website at http://africa.gov.harvard.edu/research.bates, while the data for *edu* were obtained from Barro and Lee (2000).

The data for calculating of *primary* were obtained from various issues of *United Nations' Statistical Yearbook*. Data on *civwar* and the average number of war casualties (*avdeaths*) were obtained from Singer. Data for *ethnwgur* was obtained from Gurr

The data are for the 1960–96 period and cover 43 SSA countries.[8] To reduce noise in the data and also to reduce the effects of business cycles, we took five year period averages of the data, giving us potentially eight observations for each country.[9] However, we did not have complete information for all countries for all periods. Thus we had an unbalanced panel of 220 observations for the 1960–96 period. Of the 43 countries in the sample, 13 experienced at least one period of civil war and 14 countries had at least one period of ethnic war for a total of 44 period-*civwar* and 46 period-*ethnwgurs* respectively out of a total of 220 country-periods[10]. An advantage of using the five-year averages of the variables is that it allows

[7] The ethnic war countries are Angola, Burundi, Chad, Ethiopia, Kenya, Mozambique, Nigeria, Rwanda, Sierra Leone, Somalia, Sudan, Uganda, Zaire and Zimbabwe.

[8] Sample countries are: Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo Republic, Cote d'Ivoire, Ethiopia, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Togo, Uganda, Zaire, Zambia and Zimbabwe.

[9] The last period covers two years.

[10] The list of civil wars in the sample and their duration are presented in Table A1.

the growth impact of civil war incidence not to be limited only to the period of actual fighting. We coded *civwar* as being equal to unity in any period even if there was a war for only three months out of the five-year period. Since the average civil war lasted 1.23 months per country/year, the five-year averages allow the growth impact of a civil war incidence to be spread over a reasonable period around the time the civil war is actually fought.

Summary statistics of the data are presented in Table 2. The average annual growth rate of real per capita income in the sample countries over the 1960–96 period is 0.502%, with most of the growth occurring in the 1960s. The probability of a civil war (ethnic war) incidence in a period in a country in the sample period is 0.213 (0.1269), with the average duration of civil war during the year of 1.23 months for all country/years. However, conditional on the incidence of civil war in a country, the average duration of civil war was 125 months, an average duration that is similar to those calculated by Fearon (2001) and others. Although the average duration of conflict tended to be short, average fatalities of civil

Table 2: *Summary statistics of sample data*

Variable	Mean[a]	Standard error	Minimum	Maximum
$\dot{y}$ (%)	0.502	5.072	−17.782	12.913
y (87 *PPP*$)	1086	874.44	267.4	6159.33
govcon (%)	22.78	8.17	3.46	49.97
k (%)	10.16	7.42	1.133	43.44
months	1.23	3.44	0.00	12
civwar	0.213	–	0.0	1.0
avdeaths	964.06	4171.89	0.0	39963
edu	2.08	1.228	0.276	5.57
trgdp (%)	67.131	33.8797	6.32	164.150
civ	0.3104	0.2179	0.0	0.833
legef fct	1.078	0.693	0.0	3.0
ethnwgur	0.1269	–	0.0	1.0
avemags	0.319	0.835	0.0	3.80
$N = 220$				

[a] Unweighted averages.

wars tended to be relatively high, at 964 per incidence of civil war. One striking feature of the data is the wide variation in all the variables, as evidenced by the large standard errors and extremely wide ranges in the variables.

5. Results

We used an IV estimator and the DPD98 estimator to estimate the growth equation, instrumenting for *civwar* (*ethnwgur*) with the one period forward predicted value of that variable ($pcivwar_{t+1}$, $pethnwgur_{t+1}$). In the IV estimates, we used a logit equation to obtain the predicted value of *civwar.*[11] The logit equation correctly predicted 86% (93%) of all pairs of civil war (ethnic war) incidence in the sample while the likelihood ratio test to test the null hypothesis that all slope coefficients in the logit equation are jointly equal to zero produced χ^2-statistics of 135.832 and 148.928 for the *pcivwar* and *pethnwgur* equations respectively. With four degrees of freedom, we reject the null at $\alpha = 0.01$. The correlation between $pcivwar_{t+1}$ ($pethnwgur_{t+1}$) and *civwar* (*ethnwgur*) is 0.62 (0.73).

Before presenting and discussing the estimates of the growth equation, we discuss the results of a test of exogeneity of *civwar* (*ethnwgur*) in the income growth rate equation. For the IV estimates, the test is based on a method discussed in Wooldridge (2002). We estimated the probability of civil war incidence in a year as a function of *civ*, *primary*, *lege f f*, *elf* and all other regressors in (2) and obtained a calculated error term from that equation, $\hat{v}_2$. This error term is then included as a regressor in the growth equation which uses *civwar* (*ethnwgur*) as our measure of the incidence of civil war. The coefficient of $\hat{v}_2$ in this expanded growth equation is 0.0621 (0.0432) with a calculated 't'-statistic of 1.9872 (2.062) for *civwar* (*ethnwgur*). This suggests that *civwar* (*ethnwgur*) is endogenous in the growth equation and should be treated as such. For the DPD98 estimates, Hausman statistic to test the null hypothesis that all regressors are strictly exogenous produced χ^2-statistics of 63.84 (87.59) and 81.28 (89.29) for *pcivwar* and *ethnwgur* respectively. This is consistent with the results of the exogeneity test for the IV estimates and suggests that the IV and DPD98 estimators are appropriate estimators for

[11] Estimates of the logit equation for *civwar* are presented in the Appendix and Table A2

the estimation of the growth equation in (2). For comparison purposes, we present FE estimates of the growth equation together with the IV and DPD98 estimates.

5.1. Civil War Incidence

We present and discuss the growth effect of civil war incidence in the first subsection while the second subsection discusses the growth effect of the severity of civil war. The first subsection also discusses one of several possible growth transmission mechanisms of civil war incidence. In both subsections, we discuss the growth effect of civil war on per capita GDP, as well as the growth effect on per capita GNP, to ensure that our results do not depend on the measure of income we use. We also present estimates based on *civwar* and *ethnwgur* to test whether our results are robust to the measure of civil war.

Growth Effects of Civil War

Coefficient estimates of the growth rate equation with *civwar* as an added regressor are presented in Tables 3–6. Tables 3 and 5 present the estimates of the growth rate of per capita GDP, while Tables 4 and 6 present the estimates for the growth rate of GNP per capita. Column 2 presents FE estimates of the growth equation with *civwar* as a regressor (for comparison with the IV and DPD98 estimates), columns 3 and 4 present the IV estimates, while column 5 presents the DPD98 estimates. The regression statistics in Tables 3 and 4 indicate that the growth rate equation (2) fits the data relatively well. The equation explains about 40% (20%) of the variation in the growth rate of per capita GDP (GNP) in SSA during the sample period. We reject the null hypothesis that all slope coefficient estimates are jointly equal to zero at $\alpha = 0.01$ as indicated by the *F*-statistics and the χ^2-statistic of joint significance. In addition, all coefficient estimates are of the expected signs and most of them are significantly different from zero at reasonable confidence levels. The coefficients of all time dummies (not reported) are negative and significant at $\alpha = 0.05$ or better, suggesting that the growth rate of income declined consistently during the sample period.

Table 3: *Coefficient Estimates of GDP Growth Equation, 1960–96: CIVWAR*

Variable	Coefficient estimates			
	FE	IV1	IV2	DPD98
k	0.3007 (6.08)[a]	0.4577 (5.84)	0.4541 (5.828)	0.3249 (4.52)
govcon	−0.1661 (3.68)	−0.0295 (1.87)	−0.0399 (2.481)	−0.0462 (3.01)
edu	0.1116 (1.80)	0.1789 (3.98)	0.2085 (2.66)	0.2584 (2.29)
trgdp	0.0186 (2.60)	0.0089 (2.69)	0.0128 (2.736)	0.0499 (2.89)
y_0	−0.1339 (1.67)	−0.1152 (2.05)	−0.0938 (1.938)	−0.0021 (2.06)
civwar	−1.0127 (1.97)	–	−0.9867 (1.223)	–
$pcivwar_{t+1}$	–	−7.4201 (10.629)	−8.3437 (4.819)	−4.4592 (3.506)
N	220	220	220	220
F	41.65	47.06	47.105	
$\bar{R}^2$	0.4209	0.4338	0.4329	
Jt. test of significance				71.744 [6][b]
Jt. test for Time Dums.				51.912 [6]
Sargan Test				11.314 [11]
First order ser. corr.				0.207 [44]
Hausman **m**				63.84 [6]

[a] Absolute value of asymptotic 't'-statistics computed from heteroskedastic consistent standard errors in parentheses.
[b] Degrees of freedom in brackets.

Table 4: *Coefficient Estimates of GNP Growth Equation, 1960–96: CIVWAR*

Variable	Coefficient estimates			
	FE	IV1	IV2	DPD98
k	0.4564 (6.08)[a]	0.5281 (6.218)	0.5272 (6.429)	0.5131 (6.13)
govcon	−0.2455 (3.18)	−0.1398 (3.01)	−0.1434 (2.829)	−0.0921 (2.64)
edu	0.1622 (2.81)	0.1536 (4.49)	0.2082 (4.217)	0.1871 (3.28)
trgdp	0.0115 (2.95)	0.0259 (2.16)	0.0275 (2.235)	0.0369 (2.89)
y_0	0.0019 (1.47)	−0.0021 (1.90)	−0.0021 (2.504)	−0.0018 (2.48)
civwar	−2.0126 (1.80)	–	−0.9664 (0.642)	–
$pcivwar_{t+1}$	–	−8.5640 (7.385)	−9.6821 (6.992)	−7.8921 (7.09)
N	220	220	220	220
F	16.30	24.42	24.68	
$\bar{R}^2$	0.2420	0.2787	0.2801	
Jt. test of significance				69.281 [6][b]
Jt. test for time dums.				67.471 [6]
Sargan test				13.219 [11]
First order ser. corr.				0.318 [44]
Hausman **m**				87.59 [6]

[a] Absolute value of asymptotic 't'-statistics computed from heteroskedastic consistent standard errors in parentheses.
[b] Degrees of freedom in brackets.

Table 5: *Coefficient Estimates of GDP Growth Equation, 1960–96: ETHNWGUR*

Variable	Coefficient estimates			
	FE	IV1	IV2	DPD98
K	0.3772 (4.61)[a]	0.3929 (4.404)	0.3907 (4.186)	0.2284 (4.623)
govcon	−0.1864 (2.20)	−0.1700 (2.71)	−0.1809 (2.13)	−0.0318 (1.79)
edu	0.1560 (1.62)	0.1628 (2.88)	0.1202 (1.86)	0.3954 (2.14)
trgdp	0.0323 (2.37)	0.0322 (2.34)	0.0281 (2.16)	0.0559 (2.49)
Y_0	−0.0155 (1.96)	−0.1337 (1.871)	−0.1423 (1.789)	−0.0011 (1.98)
ethnwgur	−4.0515 (2.36)	–	−3.0414 (1.44)	–
$pethnwgur_{t+1}$	–	−5.8948 (5.863)	−2.9315 (3.493)	−5.6188 (3.106)
N	220	220	220	220
F	17.29	19.89	19.98	
$\bar{R}^2$	0.1475	0.1692	0.1699	
Jt. test of significance				87.023 [6][b]
Jt. test for time dums.				56.363 [6]
Sargan test				11.58 [11]
First order ser. corr.				0.249 [44]
Hausman **m**				81.28 [6]

[a] Absolute value of asymptotic 't'-statistics computed from heteroskedastic consistent standard errors in parentheses.
[b] Degrees of freedom in brackets.

Table 6: *Coefficient Estimates Of Gnp Growth Equation, 1960–1996: Ethnwgur*

Variable	Coefficient estimates			
	FE	IV1	IV2	DPD98
K	0.5000 (6.61)[a]	0.5309 (6.714)	0.5301 (6.217)	0.4424 (5.138)
Govcon	−0.2477 (3.20)	−0.2323 (3.03)	−0.2352 (3.05)	−0.1344 (2.56)
Edu	0.1454 (1.84)	0.1734 (2.18)	0.1703 (2.17)	0.3452 (1.98)
Trgdp	0.0111 (1.61)	0.0042 (2.19)	0.0031 (2.14)	0.0826 (2.66)
y_0	0.0002 (1.69)	−0.0038 (2.26)	−0.0004 (2.29)	−0.0035 (1.68)
ethnwgur	−2.9410 (1.87)	–	−0.7778 (0.42)	–
$pethnwgur_{t+1}$	–	−6.9366 (4.674)	−6.1787 (3.782)	−5.1768 (3.14)
N	220	220	220	220
F	16.30	18.78	18.30	
$\bar{R}^2$	0.1990	0.2432	0.2376	
Jt. test of significance				91.936 [6][b]
Jt. Test for Time dums.				29.28 [6]
Sargan test				16.64 [11]
First order ser. corr.				0.365 [44]
Hausman **m**				89.29 [6]

[a] Absolute value of asymptotic 't'-statistics computed from heteroskedastic consistent standard errors in parentheses.
[b] Degrees of freedom in brackets.

The coefficients of *k*, *edu*, and *trgdp* in columns 2–5 in Table 3 are positive and significantly different from zero as $\alpha = 0.05$ or better.[12] This suggests that investment rate, openness of an economy and education have positive and significant effects on the growth rate of per capita GDP in SSA countries. The coefficient of *govcon* in columns 2–5 is negative and significant at $\alpha = 0.05$ or better, suggesting that government consumption decreases the growth rate of per capita GDP in SSA countries, all things equal. The coefficient of y_0 is negative and significant, suggesting that conditional convergence operates in SSA countries. These coefficient estimates are in accord with our expectations and are similar to the results of earlier research.

The coefficient, of *civwar* in column 2 of Table 3 is negative and significantly different from zero at $\alpha = 0.05$, suggesting that the incidence of civil war has a negative and statistically significant effect on the growth rate of GDP per capita. This negative coefficient is consistent with the results of earlier research that finds a negative relationship between civil war incidence and income growth rate (e.g., Barro, 1991; Sachs and Warner, 1997; Sala-i-Martin, 1997; Murdoch and Sandler, 2001; Atardi and Sala-i-Martin, 2003). It is also consistent with the results of research that find that ethnic tensions and strife decrease the growth rate of income in African countries (Rodrik, 1999; Easterly and Levine, 1997; Gyimah-Brempong and Traynor, 1999; Temple, 1999).

In column 3, we replace *civwar* with its instrument, $pcivwar_{t+1}$. The coefficient of $pcivwar_{t+1}$ is negative, relatively large and significantly different from zero at any reasonable degree of confidence, suggesting that the probability of civil war has a large, negative and statistically significant effect on the growth rate of per capita GDP, all things equal. Moreover, the inclusion of $pcivwar_{t+1}$ does not qualitatively change the coefficient estimates on other regressors. This suggests that the probability of a civil war has a large negative effect on the growth rate of income that is independent of the effects of other regressors. In column 4, we include both *civwar* and $pcivwar_{t+1}$ as regressors. The coefficients of *k*, *edu*, *trgdp*, *govcon* and y_0 are as expected, and most of them are significantly different from zero at 5% confidence level or better. The coefficient of *civwar* is negative but not significant at $\alpha = 0.10$, while

[12] Where we postulate an expected sign, we test the hypothesis using a one-tailed test, otherwise we use two-tailed tests.

that of $pcivwar_{t+1}$ is negative, relatively large and significantly different from zero at $\alpha = 0.01$, suggesting that the negative coefficient of $pcivwar_{t+1}$ is robust to the inclusion of *civwar* as a regressor in the growth of per capita GDP equation while *civwar* is not. The insignificance of the coefficient of *civwar* in column 4 is not surprising given its correlation with $pcivwar_{t+1}$. The IV estimates suggest that a one unit increase in civil war incidence decreases the growth rate of per capita GDP by between 7 and 8 percentage points, all things being equal. This is a very large growth effect compared to the FE estimate in column 2.

In the presence of dynamics and endogenous regressors, some researchers (e.g., Caselli *et al.*, 1996) argue that the DPD estimator produces consistent estimates while other panel estimators do not. Besides, it is possible that other regressors besides *civwar* (e.g., *k*) are also endogenous regressors in the income growth equation, thus making the IV estimates inconsistent and biased.

The DPD estimator is an IV GMM estimator that can account for the endogeneity of several regressors at the same time, hence it is appropriate when there are more than one endogenous regressor, as in growth equations. To check whether our results depend on which IV estimator is used, we used the DPD98 estimator to estimate the growth equation. A key assumption for the DPD98 estimator to produce consistent estimates is lack of autocorrelated error terms. We test for the absence of autocorrelated errors. We estimated the equation in first differences, using $pcivwar_{t+1}$ and lagged levels of other variables as additional instruments. We included time dummy variables as regressors. The DPD98 estimates are presented in column 5 of Tables 3 and 5. Test statistics indicate that there is no evidence of first order serial correlation. The Sargan test statistic indicates that the model is well specified and does not reject the over-identification restrictions, while the Hausman test statistic rejects the null hypothesis that all regressors are strictly exogenous. The test statistics suggest that the DPD98 estimator is an appropriate estimator for the growth equation in (2).

The estimates in column 5 of Table 3 are all of the expected signs and significantly different from zero at $\alpha = 0.10$ or better. In particular, the coefficient of $pcivwar_{t+1}$ is negative, relatively large and significantly different from zero at $\alpha = 0.01$, indicating that the incidence of civil war has a negative and significant impact on the growth rate of per capita GDP. Moreover, the DPD98 estimates are

closer in absolute magnitude and precision to the IV estimates in columns 3 and 4 than they are to the FE estimates in column 2. A comparison of the IV and DPD98 estimates suggests that our results stand whether we use the IV estimator or the DPD98 estimator to estimate the growth equation in (2).

The coefficient estimates in Tables 3 and 4 suggest that civil war has a negative and statistically significant effect on the growth rate of per capita income. The basic results stand whether we use *civwar* or $pcivwar_{t+1}$ as our measure of the incidence of civil war. However, there are both *qualitative* and *quantitative* differences between the FE estimates and the IV (DPD98) estimates. Generally, the coefficient estimate of $pcivwar_{t+1}$ in the IV and DPD98 estimates is about 4–5 times as large as the FE estimate. While the FE coefficient of *civwar* suggests that a unit increase in civil war incidence decreases the growth rate of per capita GDP by about 1%, the estimates in columns 3–5 suggest that a unit increase in civil war incidence decreases the growth rate of income by 7–9%. This is a very large difference. Moreover, the IV and the DPD98 estimates are more precisely estimated than the FE estimates. A Hausman test to test the null hypothesis of the equality of the FE and the IV estimates produced a χ^2-statistic of 58.629 (63.897), and that between the DPD98 estimates and their FE counterparts is 61.893. With six degrees of freedom, we reject the null hypothesis at $\alpha = 0.01$.

The large absolute difference between the FE estimate and its IV counterpart in columns 3 and 4 suggests that the correlation between the error term of the growth equation and the incidence of civil war imparts a downward bias (towards 0) to the FE estimate of the effect of civil war on the growth rate of per capita income. On the other hand, the coefficient of the instrument ($pcivwar_{t+1}$) is not so greatly affected. An alternative way to interpret the differential growth effect of *civwar* and $pcivwar_{t+1}$ is that *civwar* accounts only for the growth impact of the incidence of civil war while $pcivwar_{t+1}$ accounts for the growth impact of the incidence of civil war as well as factors that cause civil war and may depress growth rate of income. This suggests that failure to account for the endogeneity of civil war incidence leads to serious downward bias of the impact that civil war has on the growth rate of income. Therefore the FE is not the appropriate estimator for the growth rate equation. All discussions of our results will therefore be based on the IV and DPD estimates.

Do our estimates depend on the income measure used? Table 4 presents the estimates for the growth rate of per capita GNP. The ordering of the presentation of the estimates in Table 4 are similar to their counterparts in Table 3. Regression statistics indicate that our model fits the data on the growth of income in SSA reasonably well. We reject the null hypothesis that all slope coefficients are jointly equal to zero at $\alpha = 0.01$. The coefficient estimates in Table 4 are *qualitatively* similar to the estimates in Table 3. In particular, the coefficients of *civwar* and $pcivwar_{t+1}$ are negative and significantly different from zero at $\alpha = 0.05$ or better in columns 2–5 in Table 4. The order of magnitude of the coefficients of *civwar* and $pcivwar_{t+1}$ in columns 2–5 in both Tables 3 and 4 are very similar—the coefficient of the instrument of *civwar* in columns 3–5 of Table 4 is about 4–5 times as large in absolute magnitude as the estimate for *civwar* in column 2 of that table. In column 4, the coefficient of *civwar* is negative but insignificant while that of $pcivwar_{t+1}$ is negative, relatively large and significantly different from zero.

The estimates presented in Tables 3 and 4 indicate that civil war incidence has a negative effect on the growth rate of income. It is possible that our result is dependent on the measure of civil war we use. To test this possibility, we re-estimated the growth equation with *ethnwgur* as our measure of the incidence of civil war. The results are presented in Tables 5 and 6. Table 5 presents the estimates of the per capita GDP growth rate while Table 6 presents the estimates for the per capita GNP growth rate. As in Tables 3 and 4, column 2 presents the FE estimates, columns 3 and 4 present the IV estimates while column 5 presents the DPD98 estimates. All coefficient estimates are of the expected signs and most of them are precisely estimated. In particular, the coefficients of *ethnwgur* and $pethnwgur_{t+1}$ are negative and significantly different from zero, indicating that ethnic war has a negative and statistically significant impact on the growth rate of income.

As in Tables 3 and 4, the absolute magnitude of the coefficient of $pethnwgur_{t+1}$ is significantly larger, and more precisely estimated, than the FE coefficient of *ethnwgur* in both sets of income growth equations, suggesting that the FE estimate is biased downwards. Robustness test for the coefficient of *ethnwgur* produced the same results as that for the coefficient of *civwar.* Also, estimating the growth equation with both $pethnwgur_{t+1}$ and *ethnwgur* renders the coefficient of the latter variable insignificant. Hausman tests to test

the null hypothesis that the estimates in column 2 are equal to those in columns 3, 4, and 5 produced χ^2-statistics of 79.512, 69.821 and 68.913 respectively, leading us to reject the null in all cases. These exercises confirm our result from Table 3. We note that the growth impact of *civwar* is larger than the growth impact of *ethnwgur.* This may be a reflection of the fact that during the sample period, *civwars* in African countries lasted longer, involved a larger number of combatants and had more war casualties than *ethnwgurs.*

How robust is the coefficient estimate of *civwar* in the income growth rate equation presented in Tables 3–6? We conducted some robustness tests by including additional regressors in the growth rate equation to see what happens to the coefficient of *civwar*. We added *elf* to the growth rate of per capita GDP equation and re-estimated the equation. This rendered the coefficient of *civwar* insignificant. Adding *primary*, instead of *elf*, to the equation produced similar results.[13] This suggests that the coefficient of *civwar* in the growth rate equation is not robust. The basic results are also unaffected whether we measure income as per capita GDP or per capita GNP.[14]

The growth impact of civil war incidence we find in this paper appears small in absolute magnitude. It is, however, relatively large. On average, countries that had civil war in our sample grew at an annual rate of 0.5% during the sample period compared with 1.16% for those that did not experience civil war. These growth rates are very low compared with income growth rates of countries at similar stages of development in other parts of the world. United Nations data indicate that the average annual growth rate of per capita income between 1975 and 2000 for all developing countries was 2.4% while the average per capita income growth rate in SSA during the same period was −0.9% (UNDP, 2002). The 4–9 percentage point growth impact of civil war incidence we find in this study is very large relative to these average growth rates. Most SSA countries, whether they experienced civil wars or not, pursued bad economic policies during the sample period, accounting for the poor economic performance. The only SSA country that pursued good policies during the sample period—Botswana—(which also

[13] We do not present these estimates for space considerations. They are available upon request.

[14] Since $pcivwar_{t+1}$ is derived from these variables, we do not conduct this test for $pcivwar_{t+1}$.

did not experience a civil war) grew at an average annual rate of 5.1% between 1975 and 2000, compared with the SSA average of −0.9% during the same period. We also note that the growth rate of Botswana compares favourably with the growth rate of other developing countries outside SSA. Given the already poor economic performance due to bad policies, the incidence of a civil war can only make a desperate situation marginally worse. This may account for the small absolute growth effect of civil war incidence we find in this study.

Transmission Mechanism

Our estimates suggest that civil war has a negative and statistically significant effect on the growth rate of income. It does not, however, indicate the mechanisms through which this effect occurs. We mentioned above that civil war can negatively affect economic growth through several mechanisms, including reduced investment in both physical and human capital. Though our paper does not delve into the transmission mechanisms, we briefly investigate the physical capital investment mechanism. We do so by estimating a simple accelerator model of investment with civil war incidence as an added regressor. In addition to the growth rate of income, investment is likely to be positively impacted by openness of an economy since investors in open economies may have access to new technologies and more sources of investment funding than their counterparts in closed economies. Investment is also likely to be negatively correlated with government consumption on account of crowding out effect of government consumption.

We regress investment rate (k) on the one-period lag growth rate of per capita income ($\dot{y}_{t-1}$), *civwar*, *govcon* and *trgdp*. The investment equation we estimate is given as:

$$k = \gamma_0 + \gamma_1 \dot{y}_{t-1} + \gamma_2 civwar + \gamma_3 govcon + \gamma_4 trgdp + \mu \qquad (3)$$

where μ is a stochastic error term and all other variables are as defined in the text. The coefficients of *civwar* and *govcon* are expected to be negative, while those of $\dot{y}_{t-1}$ and *trgdp* are expected to be positive. As in the growth equation, we instrument for both *civwar* and *ethnwgur* in the investment equation. Coefficient estimates of this investment equation are presented in Table 7.

Table 7: *Estimates of Investment Equation, 1960–96*

Variable	Coefficient estimates	
	CIVWAR	ETHNWGUR
$\dot{y}_{t-1}$	0.1684 (3.098)[a]	0.2273 (3.982)
Govcon	−0.1718 (2.571)	−0.2386 (3.321)
Trgdp	0.0833 (4.289)	0.0783 (4.018)
$civwar_{t+1}$	−0.6865 (2.124)	–
$ethnwgur_{t+1}$	–	−4.0691 (2.382)
N	220	220
F	18.86	20.37
$\bar{R}^2$	0.3104	0.3446

[a] Absolute value of asymptotic 't'-statistics calculated from heteroskedastic consistent standard errors in parentheses.

Column 2 presents the *k* equation with $pcivwar_{t+1}$ as the measure of civil war; while column 3 presents the estimates for the equation that uses $pethnwgur_{t+1}$ as the measure of civil war.

The coefficients of $\dot{y}_{t-1}$ and *trgdp* are positive and significantly different from zero at $\alpha = 0.01$ while that of *govcon* is negative and significant, estimates that are consistent with our expectation. The positive and significant coefficient estimate of $\dot{y}_{t-1}$ suggests that investment in SSA countries can be partly explained by the accelerator model. The coefficients of $pcivwar_{t+1}$ and $pethnwgur_{t+1}$ are negative, relatively large and significantly different from zero at $\alpha = 0.05$ or better, indicating that civil war has a negative and significant effect on physical capital formation in SSA countries. The estimates of the investment equation suggest that one of the several possible mechanisms through which civil war affects income growth rate is reduced investment in physical capital.

Civil War Incidence and Income Level

Our tentative conclusion is that civil war has a relatively large, negative and statistically significant impact on the growth rate of

Table 8: *Estimates of Average Income Level Equation, 1960–96*

Variable	Coefficient estimates			
	GDP		GNP	
edu	0.0964 (4.02)[a]	0.1263 (4.508)	0.0909 (3.91)	0.1028 (3.897)
trgdp	0.0055 (5.74)	0.1144 (2.908)	0.0052 (5.79)	0.0059 (5.821)
civwar	0.1208 (1.1102)	–	–	–
$pcivwar_{t+1}$		−0.2096 (1.09)	–	
ethnwgur			0.1315 (1.468)	
$pethnwgur_{t+1}$		–		−0.2773 (1.287)
N	43	43	43	43
F	26.55	25.95	26.67	27.03
$\bar{R}^2$	.3663	.3608	.3671	.3742

[a] Absolute value of 't'-statistics in parantheses.

per capita income in SSA countries. Since our data are five-year averages, the results can be considered a short-term effect of civil war on income growth. Does this negative growth effect persist over longer periods of time? If so, then civil war should have a negative effect on the level of per capita income. We investigate this issue in a very simple way by regressing the level of per capita income on civil war, education and openness of the economy.[15] The income level equation we estimate is given as:

$$y_i = \gamma_0 + \gamma_1 edu_i + \gamma_2 trgdp_i + \gamma_3 civwar_i + \xi_i \tag{4}$$

where ξ_i is a stochastic error term and all variables are as defined in the text above. Since we are interested in the relationship between income levels and civil war incidence across nations, we estimate a cross-section regression using the sample period averages of the variables. There are, therefore, 43 observations for this regression, which is estimated by Ordinary Least Squares (OLS).

[15] Although this is a crude way to investigate the income level–civil war relationship, it is useful since we are only interested in the correlation between the two variables. We believe that this simple gravity-type equation can at least indicate the direction of the relationship.

The coefficient estimates of the income level equation are presented in Table 8. Columns 2 and 3 present the estimates for the GDP per capita equation, while columns 4 and 5 present the estimates for the per capita GNP equation. The column 2 and 4 estimates are based on the measure of civil war (*civwar*, *ethnwgur*), while columns 3 and 5 present the estimates based on the instruments of civil war ($pcivwar_{t+1}$, $pethnwgur_{t+1}$). The equation explains about 40% of the cross-country variation in income level and we reject the null hypothesis that all coefficient estimates in the income level equation are jointly equal to zero at any reasonable confidence level in all equations. The coefficients of *edu* and *trgdp* in the equation are positive and significant, indicating that education and openness are positively correlated with the level of income in SSA countries.

None of the coefficient estimates of the indicators of civil war (*civwar*, $pcivwar_{t+1}$, *ethnwgur*, $pethnwgur_{t+1}$) are significant in the income level equation, indicating that civil war has no significant correlation with the level of per capita income. It is possible that civil war decreases the growth rate of income during and immediately after the war, but there after, reconstruction leads to an acceleration of economic growth. This leads to income levels catching up with those of countries that never had a civil war. While we are not able to test this conjecture, we use a few examples to illustrate this point. Nigeria's economy barely grew in the period before the Biafran war. Growth rate of the Nigerian economy averaged about 8% per annum in the decade following the civil war, after which the economy stagnated. Chad's economy grew at an average rate of 5.7% immediately after the 1980–8 civil war, five times faster than the growth rate before the civil war and the period after. Similar observations can be made about the growth rate of GDP in post-conflict Burundi (after 1972 conflict), Mozambique (after 1994) and Uganda (after 1988). One way to interpret these results is that, once one accounts for the correlation between income levels and education and trade policies (factors that are also correlated with civil war incidence), one does not find a significant correlation between civil war incidence and the level of income.

It is also possible that civil war incidence, indeed, is significantly and negatively correlated with the level of income across countries. However, our methodology and data cannot determine this. This is especially the case when average per capita incomes in SSA

countries (both civil war and non-civil war countries) were decreasing due to economic stagnation and rapid population growth during the sample period. Perhaps a more sophisticated methodology and a richer data set could uncover this relationship. The estimates here are, however, consistent with the results of earlier cross-country growth research that finds no significant relationship between income level and the incidence of civil wars. It is clear that the relationship between the incidence of civil war and cross-national variation in income levels needs further investigation, an agenda we hope to take on in a different research project.

There is an alternative way to interpret the insignificant relationship between civil war and the level of per capita income. It is possible that income growth and therefore long-run income levels are determined by country heterogeneity not captured by civil war and that relatively high income countries in our sample have a lower propensity for civil war incidence. Hence the insignificant relationship we find between income levels and civil war incidence in this study says nothing about the long-term effect of civil war incidence on economic well being. Of course, it is possible that we have misspecified the relationship between the level of income and the incidence of civil war.

5.2. Growth Effects of Civil War Intensity

The analysis above has focused on the incidence of civil war, which ignores the intensity of civil war. A war that lasts a long time and has more fatalities is likely to have a more deleterious growth effect than one that lasts for a short period of time with few casualties. We therefore investigate the effect of civil war severity on the growth rate of per capita income. The Minorities at Risk data from which we obtained *ethnwgur* provide an overall score for the intensity of a civil war (*avemags*). This variable is a composite of conflict duration, war casualties, average number of combatants and portion of the country geographically covered by the civil war. The scale ranges from 0 to 4, with 0 implying non-existence of war or no intensity and 4 being the most intense conflict. We re-scaled *avemags* in the following way. We created two dummy variables: *MAG*1,which takes the value of one if *avemags* is between 0.2 and 1.5, zero otherwise to represent moderate severity, and *MAG*2,which represents severe civil war intensity and takes the value of unity

if *avemags* is greater than 1.5, zero otherwise. We used these dummy variables to measure the effect of severity of ethnic wars on the growth rate of per capita income in SSA. The control group are countries with *avemags* score of 0.2 or less.

The *civwar* data did not have a composite variable for the severity of conflict; it only provides total war casualties for the entire duration of the conflict. We created two measures of civil war severity from the civil war data. Our first measure was created as follows: we took the product of average duration of civil war in a period (in months) and the average number of war deaths in the period.[16] If the product of war duration and war fatalities is greater than zero but less than or equal to 15,000 per period, we call it *LOWINT*, a dummy variable that equals one, zero otherwise. If the product is greater than 15,000, we call it *HIGHINT* and assign a value of one, zero otherwise. The excluded group are countries whose product of war duration and war fatalities equal zero. The second index we created is the normalised first principal component formed from the combination of *months* (the average duration of civil wars) and the number of war fatalities. Since we normalise the principal component, it is a z score of civil war severity, hence it should be interpreted as the number of standard deviations from the mean of civil war severity. We label this variable *prin*1.[17]

Coefficient estimates of the war intensity equation are presented in Table 9.[18] Columns 2 and 3 present the estimates for *civwar*, while column 4 presents the estimates for *ethnwgur*. The coefficient estimate of *prin*1 is negative, relatively large and significantly different from zero, suggesting that, conditional on civil war incidence, growth rate of per capita income decreases with the severity of civil war, all things being equal. A one standard

[16] The *civwar* data gives only total number of war casualties for the entire duration of the conflict. It is possible that a civil war spans more than one period in our sample. In such cases, we divide the number of war casualties among the periods in proportion to the duration of the conflict in each period. Though not an exact way of counting the number war casualties, this is a more reasonable approach than any other alternative.

[17] We admit that the way we measure civil war intensity is rather crude. However, given our data, we are not able to provide any refined measure of civil war intensity. We note that our measure will provide at least an indication of the effect of civil war intensity on growth.

[18] We do not present the full estimates of this equation. We only present the coefficient estimates of interest.

Table 9: *Growth Effects of Civil War Intensity, 1960–96*

Variable		Coefficient	Estimates
PRIN1	−0.7817 (2.880)[a]	–	–
LOWINT	–	−1.043 (2.148)	
HIGHINT		−1.516 (2.192)	–
MAG1	–		−0.4892 (1.922)
MAG2	–	–	−0.6305 (1.992)
N	220		

[a] Absolute value of asymptotic 't'-statistics calculated from heteroskedastic consistent standard errors in parentheses.

deviation increase in the severity of a civil war decreases the growth rate of per capita income by about 0.8 percentage points in a period. The interpretation of the coefficient of *prin*1 is, however, problematic since there is no unit of measurement. It is not clear what a standard deviation change in *prin*1 represents in terms of war intensity. One cannot therefore use the coefficient estimate to make policy inference about the effect of any particular variable, such as civil war fatalities or war duration, on the growth rate of per capita income. It is, however, indicative of the negative effects civil war intensity has on the growth rate of income.

Column 3 presents the coefficient estimates of *LOWINT* and *HIGHINT*. Both coefficient estimates are negative and significantly different from zero at $\alpha = 0.10$ or better. Moreover, the coefficient of *HIGHINT* is larger in absolute magnitude than that of *LOWINT*, suggesting that the negative growth effect of civil war increases with the severity of war. Column 4 presents the estimates for *MAG*1 and *MAG*2. The coefficient estimates for both variables are negative and significantly different from zero suggesting that the severity of ethnic war has a negative effect on the growth rate of income. The pattern of these coefficient estimates are similar to those of *LOWINT* and *HIGHINT* in column 3 in the sense that the coefficient estimate for the high-intensity index is larger in absolute magnitude than the estimate for the low-intensity index. This suggests that the growth-reducing effect of ethnic war severity increases at an increasing rate.

5.3. Discussion

Based on the IV and DPD98 estimates presented in Tables 3–6, we conclude that civil war incidence has a significantly negative and robust effect on the growth rate of per capita income in SSA countries. However the civil war-income growth relationship is robust only if the researcher accounts for possible endogeneity of civil war incidence. By accounting for the endogeneity of civil war incidence, we are able to resolve the non-robustness issue noted by Levine and Renelt (1991). We also find that one of the mechanisms through which civil war incidence decreases the growth rate of income is decreased investment in physical capital. In addition, we show that the severity of civil war has negative and statistically significant effect on the growth rate of income quite apart from that of the incidence of civil war. The growth effect of war intensity increases at an increasing rate with war intensity. The growth impact of civil war, however, is possibly a short-run phenomenon. Our results are qualitatively similar to those of Murdock and Sandler (2002) and Artadi and Sala-i-Martin (2003). However, there are some quantitative differences. Our IV and DPD98 estimates of the growth impact of civil war are much larger in absolute magnitude than theirs. The growth effects of civil war we estimate in this study are likely to be lower bound estimates since we do not account for other possible effects, such as reduced human capital formation.

Our results have both research and policy implications. From a research perspective, it is necessary for researchers who use the incidence of civil war as a regressor in growth equations to account for the endogeneity of civil war incidence. This can be achieved by either estimating a structural equation or by using estimation methodologies that account for the endogeneity of civil war incidence. Secondly, researchers should distinguish between the growth effects of civil war incidence and that of the severity of civil war as they have separate growth effects. Thirdly, researchers should explore the mechanisms through which civil war affects income growth.

Given the existence of the stable, robust, negative impact of the incidence of civil wars on income growth we find in this study, one way to increase the growth rate of per capita income in African countries is to reduce the incidence and severity of civil wars there.

While we do not deal with the causes of the initiation or duration of civil wars, and hence are not in a position to suggest remedies for reducing the incidence of civil war, the civil war literature suggest a few possibilities. These include a concerted effort to reduce the proliferation of small arms trade, refusal by neighbouring countries to give sanctuary and material help to insurgents, increasing the defence capabilities of central governments, as well as increasing the capabilities to mediate and resolve conflicts. Increasing economic opportunities for would-be combatants (employment and schooling and training opportunities for young people and denying war related benefits for potential war lords') and increasing the cost of war to the combatants generally may reduce the incidence and hence the cost of civil wars. Combatants will not initiate conflicts or continue to fight if the cost of conflicts exceed any possible benefits gained. Some of these efforts to reduce the incidence of civil wars in African countries will involve regional and international cooperational.

The need to reduce civil wars as a means of spurring economic growth is especially important in SSA where economic resources are scarce, the need for rapid economic growth is pressing and civil wars abound to compound human misery. Although the impact of civil war on income may be short term in nature, African political leaders, the international community and other policy makers interested in improved economic prospects for African countries should still focus on measures to counter the effects since the short run could be relatively long. Better still, the policy makers should focus on avoiding civil wars *per se*, not only to spur economic growth, but also to reduce human misery directly caused by civil wars.

6. Conclusion

This paper investigated the effects of the incidence and severity of civil wars on the growth rate of per capita income and the robustness of such effects in SSA. Using panel data from a sample of 43 SSA countries for the 1960–96 period and IV and DPD estimators, we find that the incidence of civil war has a significant negative effect on the growth rate of per capita income, all things being equal. However, the robustness of the relationship disappears if one does not account for the possible endogeneity of civil war. Civil war has a negative growth effect partly through reduced physical capital

formation. We also find that the severity of civil war has a negative effect on the growth rate of per capita income that is different from the growth effect of civil war incidence. It is therefore necessary to distinguish between the two factors: the growth effects of the incidence and of the severity of civil wars. Our results have implications for growth research and policies to promote economic growth in SSA.

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Appendix: Logit Estimates of the *CIVWAR* Instrument

The regressor of interest in this paper is *civil war incidence*, instrumented with the one-period lead of the predicted probability of civil war ($pcivwar_{t+1}$). We think of civil war incidence as a latent variable, propensity for civil war (y^*), which can occur in any SSA country. This latent variable is a continuous function of some underlying socio-political factors. We write the latent as: $y* = \Lambda(X) = X'\beta + \varepsilon$, where X and β are vectors of regressors and coefficients. However, this latent variable y^* is only observed when a civil war occurs in a country; it is zero otherwise.

The 'threshold' equation can be written as:

$$y_i = \begin{cases} 1 & \text{if} \quad y_i^* > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

The conditional mean of the latent variable y_i^*, $(E(y_i^*|X_i)$, is given by the function $X'\beta + \varepsilon$. The link function we use for this nonlinear $\Lambda(X)$ function is the logit function. The odds-on chances of civil war occurring in a country is therefore given by:

$$pcivwar_t = \frac{\exp\left(\sum_{j=0}^{J} \beta_k X_{ik}\right)}{1 + \exp\left(\sum_{j=0}^{J} \beta_k X_{ik}\right)} \tag{7}$$

As argued in the paper, the elements of X are the index of civil liberties (civ), primary export dependency (primary), legislative effectiveness (*legeffct*) and ethnolinguistic fractionalisation (*elf*). We are more interested in the correlation of these variables with *civwar*

(*ethnwgur*) than in the causal relationship between these variables and civil war incidence. Hence the logit equation should be judged on its ability to predict the probability of civil war occurrence rather than on a causal relationship between these variables and the incidence of civil war.

The logit estimates of the *civwar* and *ethnwgur* equations are presented in Table A2. Column 2 presents the estimates for *civwar* while column 3 presents the estimates for *ethnwgur*. The regression statistics indicate that the four variables strongly predict the probability of the incidence of civil war in our sample. The likelihood ratio statistic rejects the null hypothesis that all slope coefficients are jointly equal to zero at $\alpha = 0.01$ or better and each of the slope coefficients is significantly different from zero at $\alpha = 0.05$ or better. More important for our paper is that the equation correctly predicts the probability of civil war (ethnic war) incidence in about 88% (92%) of the cases. This leads us to conclude that our instruments are 'strong' instruments.

Table A1: *Civil War Countries: 1960–96*

Country[a]	Years	Rebel group
Angola	1975–94	UNITA
Burundi	1972, 1991–3	Hutu, FROLINAT, Other
Chad	1965–88	Various Groups
Ethiopia	1961–4, 1974–91	Various Groups
Mozambique	1976–93	RENAMO
Nigeria	1967–9	Biafra
Rwanda	1990–4	FPR
Sierra Leone	1991–3, 1994–7	RUF
Somalia	1981–95	SSDF, SNM, Various Groups
Sudan	1963–71, 1983–96	AN, SPLM, NDA
Uganda	1980–8, 1989	Various Groups
Zaire	1960–2, 1963–5, 1978	Katanga, Kasai, CNL, AFDL
Zimbabwe	1972–9	ZANU, ZAPU

[a] Some countries that experienced civil war during the period, such as Liberia, are not included because of lack of data on economic variables.

Table A2: *Logit Estimates of Civil War Probability*

Variable	Coefficient	Estimates[a]
Civ	13.0841*** (18.8926)[b]	11.8916*** (16.8912)
Primary	1.0036*** (6.1019)	2.1897 (10.6291)
legef fct	−0.7304*** (11.7949)	−0.9228 (10.8971)
Elf	2.1961*** (6.7617)	3.5971 (10.9221)
N	220	
Likelihood ratio	135.8325 [8][c]	148.9278 [8]
Score	86.1573 [8]	92.8912 [8]
Wald	51.0106 [8]	59.0982 [8]
Percent concordant	88.2	92.86
Somer's D	0.826	0.898

***Significantly different from zero at $\alpha = 0.01$.
[a] All estimates include time dummy variables.
[b] χ^2-statistics in parentheses.
[c] Degrees of freedom.