ECONOMIC GROWTH, CIVIL WARS, AND SPATIAL SPILLOVERS

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Final Draft: July 2001

AUTHOR'S NOTE: Murdoch is the Director of the Bruton Center; Sandler is the Robert R. and Katheryn A. Dockson Professor of International Relations and Economics. The research for this paper was funded, in large part, by a grant from the Development Research Group of the World Bank. All opinions expressed are solely those of the authors. We have profited from the comments of two anonymous referees.

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Abstract

The paper relies on a neoclassical growth model to empirically test for the influences of a civil war on steady-state income per capita both at home and in neighboring countries. Moreover, this model provides the basis for measuring long-run and short-run effects of civil wars on income per-capita growth in the host country and its neighbors. Evidence of significant collateral damage on economic growth in neighboring nations is uncovered. Additionally, this damage is attributed to country-specific influences rather than to migration, human capital, or investment factors. As the intensity of the measure used to proxy the conflict increases, there are enhanced neighbor spillovers. Moreover, collateral damage from civil wars to growth is more pronounced in the short run.

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> The most formidable challenge to the international security system at the global and regional levels is the fragility and erosion of the states which are not capable of managing developments on their territory…. The strength and effectiveness of state institutions and structures are reduced most often in poor countries torn apart by civil wars and centrifugal tendencies. Rotfeld (1999, 1)

Even during times of relative peaceful co-existence among major powers, civil wars with 1000 or more battle deaths have plagued nations throughout this century (Singer and Small 1993). In 1998, there were 25 major civil wars raging in Africa, Asia, and elsewhere (Sollenberg, Wallensteen, and Jato 1999). Since 1960, almost all civil wars have been in developing countries, whose economic growth and development are apt to be impeded by the resulting human capital losses, reduced investments, infrastructure destruction, and market-activity disruptions. Both battle deaths and soldiering mean less human-capital formation, while demands for weapons divert savings into activities with relatively little investment payback, especially in countries not at the forefront of weapon design. Civil wars can drive away foreign direct investment, an important source of savings, as foreign investors redirect their funds to less risky and more politically stable countries. Moreover, battles and guerilla activities can destroy private and social capital while inhibiting market exchanges. The long-run and short-run economic prospects of civil war-torn nations are adversely affected by such hostilities.

It is unlikely that the economic consequences of civil wars will be solely confined to a nation in turmoil. There is apt to be negative spillovers to neighboring nations from disruptions to trade, heightened risk perceptions by would-be investors, severance of input supply lines, collateral damage from nearby battles, and resources spent to assist refugees. The length and accessibility of common borders are anticipated to determine the spatial transmission of negative externalities stemming from a neighbor's internal conflict.[1]

A better understanding of the consequences of civil wars, not only on a host country's economic growth but also on its neighbors' growth, is essential to improve the effectiveness of foreign assistance to developing countries. When neighborhood spillovers are substantial, this assistance may have to be augmented to counteract civil war externalities for an aid-recipient nation to stay on its path to a higher steady-state level of gross domestic product (GDP) per capita. Analogously, aid decisions need to address the direct consequences on economic growth in countries experiencing civil wars.

This paper has three primary purposes. First, a theoretical model is presented that can provide alternative reduced-form equations for estimating the direct and neighborhood effects of civil wars on economic growth. The theoretical representation is the neoclassical growth model of Mankiw, Romer, and Weil (1992) that is slightly modified to include civil war influences. Unlike many recent analyses of growth (Forbes 2000; Hanushek and Kimko 2000), our estimating equations derive from an explicit antecedent theoretical model. Second, the paper contains three alternative empirical specifications for a cross-section of nations during 1960-90. Model 1 concerns the impact of civil wars on the long-run steady-state level of GDP per capita;[2] Model 2 involves the effect of civil wars on the long-run growth of GDP per capita; and Model 3 investigates the influence of civil wars on the short-term growth of GDP per capita. In all cases, the *spatial dispersion* of a civil war's impact is included. Third, the paper draws policy conclusions in light of the empirical findings.

We find that civil wars have significant, but modest, negative influences on the steady-state level of GDP per capita, both at home and in neighbors. Using a nonlinear model, we rule out that the negative civil war impact upon neighbors works through the labor term, human capital, or investment; thus, we assign this impact as a country-specific effect. As the intensity of the civil war measure increases, there is evidence of greater collateral damage to neighboring countries. This harmful impact on growth is rather large for civil conflicts with more than 25,000 deaths. In pooled estimates over six five-year periods, civil wars have strong contemporaneous direct and spatial consequences on growth; moreover, there is little evidence of lagged effects. The growth convergence term indicates that nations, most destroyed by a civil war, will rebound more fully.

THEORETICAL MODEL

In providing a theoretical basis for the effects of a civil war on a nation's growth, we utilize the Solow (1957) neoclassical growth model that is augmented to include human capital (Mankiw, Romer, and Weil 1992). The foundation for such a growth model is a neoclassical production function, for which diminishing returns (i.e., decreasing marginal product) apply to all three inputs: labor (L), physical capital (K), and human capital (H). Constant returns to scale characterizes the Cobb-Douglas production function of the model,[3] so that the same proportional increase in all inputs results in an identical proportional increase in output. Along the steady-state growth path, savings equal total investment in physical and human capital. To the associated empirical model, we add the potential influences of a civil war either within the country or in a neighboring country, from which disruptions to investment, human capital formation, and political stability may spill over. Unlike most other recent analyses of civil wars, the theoretical model that underlies our empirical work is one of *economic growth*.[4]

SOLOW MODEL AUGMENTED BY HUMAN CAPITAL

Recent studies of economic growth have demonstrated the importance of human capital as a determinant of income per capita and its growth (see, e.g., Aghion and Howitt 1998; Aghion, Caroli, and García-Peñaloso 1999; Barro 1991; Barro and Sala-i-Martin 1995). The human-capital-augmented production function that relates output (income), $Y(t)$, at time t to inputs is:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} [A(t)L(t)]^{1-\alpha-\beta}, \qquad 0 < \alpha + \beta < 1, \quad (1)$$

where α and β are the elasticities of output with respect to capital and human capital, respectively. $A(t)$ denotes the level of technology embodied in labor, and $(1 - \alpha - \beta)$ indicates the output elasticity of effective units of labor, $A(t)L(t)$. Labor-embodied technology progresses at the exogenous rate of g, whereas labor grows at the exogenous rate of n. Division of both sides of equation (1) by effective labor gives an expression of income per effective unit of labor, $y = Y/AL$, that equals:

$$y(t) = k(t)^{\alpha} h(t)^{\beta} \quad (2)$$

with $k = K/AL$ and $h = H/AL$, where t is suppressed.

To complete the model, we need the transition equations for physical and human capital. For simplicity, both forms of capital are assumed to depreciate at the identical rate δ. Each transition equation follows from expressing either the time rate of change of capital ($\dot{K} = dK/dt$) or human capital ($\dot{H} = dH/dt$) in effective labor units as the difference between the share of income devoted to K or H less depreciation. Based on standard substitutions, the transition equations are:[5]

$$\dot{k}(t) = s_k y(t) - (n + g + \delta)k(t), \quad (3)$$

and

$$\dot{h}(t) = s_h y(t) - (n + g + \delta)h(t), \quad (4)$$

where s_k (s_h) is the share of income invested in physical (human) capital, $h = H/AL$, and other symbols are as previously defined. At the steady-state solution where $\dot{k} = \dot{h} = 0$, equations (3)-

(4) imply a convergence to the stationary values:[6]

$$k^* = \left(\frac{s_k^{\;1-\beta} s_h^{\;\beta}}{n + g + \delta} \right)^{1/(1-\alpha-\beta)} \tag{5}$$

and

$$h^* = \left(\frac{s_k^{\;\alpha} s_h^{\;1-\alpha}}{n + g + \delta} \right)^{1/(1-\alpha-\beta)} . \tag{6}$$

These steady-state values of k and h are then substituted into the production function when expressed as

$$Y(t)/L(t) = A(t) k^{\alpha} h^{\beta} . \tag{7}$$

After taking logs of the resulting equation, we have the equation that underpins our steady-state per-capita income estimates:

$$\ln \frac{Y(t)}{L(t)} = a + gt + \frac{\alpha}{1-\alpha-\beta} \ln s_k + \frac{\beta}{1-\alpha-\beta} \ln s_h - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n + g + \delta) , \tag{8}$$

where $A(0)$ is set equal to a constant, a. In equation (8), the shares of income invested in physical or human capital have a positive influence on steady-state per-capita real income, whereas the growth of labor, labor-embodied technical change, and depreciation have a negative influence on steady-state per-capita income. Any augmentation to labor increases the denominator of $Y(t)/L(t)$ and this reduces per-capita income. The coefficients in front of the income shares and the labor term are both ratios of the output elasticities with respect to the inputs. The *sum* of the coefficients on the two investment share terms is equal, but opposite in sign, to the coefficient on the $(n + g + \delta)$ expression.

This model can be easily extended to allow for migration, which may affect income per capita through two possible channels. If the migrants bring in human capital, then s_h and, thus, income per capita can be increased. In a civil war scenario, refugees typically bring in little usable human capital and, hence, we ignore this potential influence. The more relevant impact of civil war-related migration is to increase population so that its growth is $m+n$, where m is the growth in migration. In equation (8), $\ln(m+n+g+\delta)$ then replaces $\ln(n+g+\delta)$, so that migration serves to further decrease steady-state income per capita.

At times, it is convenient to express the estimating equation as a growth rate or the difference between the natural log of income per capita at two points of time, denoted by $y(t)$ and $y(0)$, where $y(0)$ is some initial value. If the speed of convergence to the steady-state income per capita value of y^*, from an actual value of $y(t)$ at time t, is λ, then the growth in income per capita from some initial value is:[7]

$$\ln y(t) - \ln y(0) = (1-e^{-\lambda t})\ln y^* - (1-e^{-\lambda t})\ln y(0). \qquad (9)$$

Equation (9) represents a log-linearized approximation for the transition of per-capita income to its steady-state value. If we substitute for $\ln y^*$ using equation (8), while ignoring gt at the steady-state, we obtain:

$$\ln y(t) - \ln y(0) = a + (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln s_k + (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln s_h$$

$$-(1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) - (1-e^{-\lambda t})\ln y(0). \qquad (10)$$

The big difference between the estimating equation for steady-state income per capita in equation (8) and that for the growth of income per capita in equation (10) is the appearance of the initial income per capita term. This latter determinant weighs a negative influence on growth owing to the assumption of diminishing returns, and is responsible for convergence, where the growth rate of the poorer country outpaces that of the rich country. The latter occurs when two countries possess identical production functions and transition equations, but have different initial values of income per capita (Barro 1991; Barro and Sala-i-Martin 1992, 1995).

Two alternative representations for the dependent variables of such growth equations exist in the literature depending on whether long-term or short-term growth influences are being quantified. For a long-term investigation, the difference of the natural logs of income per capita separated by 20 to 25 years is appropriate (Barro 1991); while, for a short-term examination, this difference involves 4- to 5-year intervals (Burnside and Dollar 2000; Forbes 2000). Moreover, the short-term difference of logs of income per capita is divided by the number of years so that the dependent variable corresponds to the *average* growth rate of *y* per year during the relevant period. We shall also apply this approach to some of our cross-section estimates.

CIVIL WAR INFLUENCES

There are a number of theoretical reasons why a civil war may adversely influence the steady-state level and growth of a country's income per capita. A civil war at home may result in a loss of physical and human capital, which then reduces steady-state income per capita. Civil wars may also divert foreign direct investment owing to the added risk that the conflict presents to potential investment opportunities. In addition, military spending on the conflict is apt to channel money away from more growth-promoting activities. Through the daily disruption to market exchanges, civil conflict will also adversely affect economic activities and, hence, income per capita. Some of these same factors, along with others, may also reduce income per capita and its growth in neighboring nations. A nearby civil war may lead to collateral damage from battles close to the border that destroy infrastructure and capital. Surely, civil wars within the vicinity may heighten perceived risks to would-be investors and divert foreign direct investment away from neighbors at peace. These neighbors must also expend resources to secure their borders from rebel incursions – an action that may result in less productive use of resources. As mentioned previously, nearby civil wars can increase refugee flows, which raises labor growth and reduces per-capita income through migration. Neighboring civil wars can also disrupt trade flows and sever crucial input supply lines.

In terms of the estimating equation, there are four channels – human capital, physical capital, labor growth, and an intercept shift – through which civil wars at home or abroad may affect steady-state income per capita and its growth. We devise a few tests to pinpoint how civil wars affect steady-state income per capita. For the human capital channel, we test for an interaction between the civil war measure and human capital. For investment, we add an investment equation with civil war as an influence and test whether it has a significant effect. For the labor growth influence, we introduce the civil war measure as a proxy for migration m in the $\ln(m + n + g + \delta)$ term and then estimate the resulting equation. The intercept influence is captured by merely introducing the civil war measure as a separate term in the estimating equation. A nonlinear joint test between the migration-based and intercept-based estimates allows us to choose between these alternative channels. The outcome of these tests are reported in the results section.

DATA

The data used to estimate the parameters of the various specifications comes from four sources: (i) the Penn World Tables Mark 5.6 (PWT 5.6), which is an update of the data described in Summers and Heston (1991); (ii) Barro and Lee (1996); (iii) personal correspondence with Nicholas Sambanis of the World Bank; and (iv) the Correlates of War Project (COW), Part 2: Civil Wars (Singer and Small 1993). Table 1 gives the raw variables' names, brief descriptions, and sources, whereas Table 2 provides the derived variables' names and descriptions. Below, we give an overview of the main variables of the analysis.

We use the real GDP per capita in constant dollars (the variable "RGDPCH" in PWT 5.6) for the empirical measure of income per capita (*y*). To distinguish the various years, we attach the last two digits of the year; thus, *y*60 is the measure of income per capita in 1960. The average investment share (invest) is the arithmetic average of the investment shares (the variable "I" from PWT 5.6 expressed as a proportion) for all years in the period. Annual population growth is computed as the natural logarithm of the ratio of the ending value to the starting value divided by the number of years. For example, the annual growth of labor for 1960 to 1985 is proxied by ln(pop85/pop60) ÷ 26, where the population data are taken from PWT 5.6 (the "POP" variable).

To capture the effect of human-capital accumulation, we employ the level of human capital as measured by the percentage of the population older than 25 that has attained secondary school (Barro and Lee 1996). Mankiw, Romer, and Weil (1992, 418) indicate that the human-capital-augmented growth model may rely on either the rate of human-capital accumulation or the level but that some care must be exercised in interpreting the coefficients. Thus, our model corresponds most closely with their equation (12). The attainment data is available quinquennially with the last two digits of the year identifying the year so that s60, for example, denotes the attainment in 1960.

The World Bank provided an additional variable that may control for previously unobservable country effects. The ethno-linguistic fractionalization index (elfo) is constructed to approximate the probability that two randomly selected persons will not speak the same language, and has been used in other analyses of civil wars.[8] A value of zero indicates that everyone speaks the same language, while a value of 100 indicates complete linguistic heterogeneity. The elfo index is a proxy for the potential polarization in a society, which can inhibit economic exchange, cooperation, and activity levels, thereby reducing income per capita or growth.

The remaining variables concern the existence, duration, and severity of civil wars. The COW data provides the starting and ending dates as well as the battle deaths for civil wars that began before 1989. We use these data to determine the years, the number of months in each year, and the number of war deaths in each month that a country experienced during a civil war. The monthly number of deaths represents an average that is computed by dividing the total number of deaths from the civil war by the duration of the war in months. This procedure facilitates "annualizing" the civil war variables in cases where a civil war ended and another started in the same year or in instances where civil wars overlapped in time within a particular country. Then, depending on which model we wish to estimate, we are able to construct the civil war variables: (i) civ, representing a dummy variable equal to one during civil war years; (ii) tmonths, giving the total number of months of civil war in a country; (iii) tdeaths, indicating the total number of deaths from civil wars; and (iv) deathdum, denoting whether civil war deaths exceeded 25,000. The tdeaths variable is based on the average death rate for the entire civil war episode. The last three measures involve the severity of the internal conflict. Because these measures of civil wars are highly correlated, it is appropriate to employ only one in any estimation.

As an example of the construction of the civil war variables, consider a situation where we wish to study the effects of changing the sample period lengths from (say) 1960-69 (a ten-year length) to two five-year lengths. In the first case, civ would indicate if a country experienced a civil war at any time during 1960-69, and tmonths would measure the total number of months over the period. By changing the sample period length, we must re-compute civ for each period so that we know if the country experienced civil war (and for how long) during 1961-65 and/or 1966-70. The annualization is crucial for this calculation, because the original COW data simply give starting and ending dates for particular episodes and the total battle deaths. Thus our procedure enables us to handle cases where, for example, a civil war started in

1963 and ended in 1968.

Our focus is on the own-country effects and the spillover effects from civil wars in neighboring countries. We measure the spillover effects using a weighted average of the civil war measures in neighboring countries, where the weights reflect the length of common borders. A civil war measure in a neighboring country with a long common border will get more weight than will be the case in a neighbor with a shorter common border. Quite simply, lengthier common borders provide more entry points for collateral damage. Specifically, the weight attached to country *i*'s *j*th neighbor is the ratio of the length of the border between *i* and *j to* the entire border length of country *i*; hence, the weights sum to one. To denote the spatial spillover measures,[9] we prefix the respective civil war term with "w_," giving w_civ, w_tmonths, w_death, and w_deathdum. It is essential to note that using this concept of neighbor means that no weight is given to civil wars in noncontiguous countries.

To find the common borders, we consult the *CIA* (2000) *Factbook*. Unfortunately, some of the borders have changed since 1990; e.g., Yugoslavia. In such cases, various paper atlases are consulted in order to reconstruct the geography of the countries in 1990 and the sample is restricted to include nations that had constant geography from 1960 through 1990. The sample of nations and some of the civil war variables are presented in the Appendix.

EMPIRICAL SPECIFICATIONS

To study the impact of civil wars on economic growth, we examine three sets of different specifications of the growth process, which address short- and long-run effects of a civil war. This temporal distinction is important, insofar as civil wars' influences may be transitory or long-lasting. A knowledge of such influences' temporal nature is essential for informed policy to mitigate negative impacts. The first set is referred to as "Model 1 variations," which are derived from the neoclassical model and which describe the steady-state level of income per capita (equation (8)). In terms of the data and variables, we can express the statistical model for equation (8) as:

$$\ln(y85_i) = \gamma_0 + \gamma_1 \ln(\text{invest}_i) + \gamma_2 \ln(n_1 + g + \delta) + \gamma_3 \ln(s\text{xx}_i) + \varepsilon_i, \tag{11}$$

where $g + \delta = 0.05$ (Mankiw, Romer, and Weil 1992), *s*xx indicates some measure of educational attainment, and the *i* subscript denotes the country. To estimate this model, we use data from 1960 to 1985; thus, invest_i is the average investment share over the 26-year period and n_i is the average annual growth in population. For the schooling variable, we consider preliminary estimates using s60, s70, and s85 as well as the average over the sample period. The average value offered a slightly better fit in terms of lower standard error and higher *R*-square; therefore, we use the average (s_ave) in subsequent estimations. Since human capital is anticipated to change during a civil war, this average over the sample period is also best suited for the task at hand.

We considered several preliminary specifications of equation (11), based on alternative sets of country-specific measures, including those of religious fractionalization, population dispersion, and an African continent dummy variable. These estimates are available at *http://www.bruton.utdallas.edu*. None of these additional variables is significant when the ethno-linguistic fractionalization index (elfo) is included in the model; hence, only elfo is included with the macroeconomic measures in defining the benchmark specification, from which we add the various measures of civil war existence, duration, and severity in the home country and its neighbors.

The second set of specifications (Model 2 variations) is based on the long-term growth in income per capita as shown in equation (10). Model 2 addresses the transition to the steady state from an initial level and has been widely employed in the literature to test for income per capita convergence. Our interest is more concerned with comparing the results from the long-term model (Model 2) to a model that is based on shorter time periods (our Model 3).

Using the benchmark specification from above, we can represent Model 2 as

$$\ln(y85_i) - \ln(y60_i) = \varsigma_0 + \varsigma_1 \ln(y60_i) + \varsigma_2 \ln(\text{invest}_i) + \varsigma_3 \ln(n_i + g + \delta)$$
$$+ \varsigma_4 \ln(\text{sxx}_i) + \varepsilon_i \,. \tag{12}$$

In this model, we generally find that *s*60 offers the best fit although the schooling variables are never significant in this specification, a finding not unlike that of Burnside and Dollar (2000, 850). Once again, elfo is added as an independent variable and then the various civil war terms are also included.

The third specification is a panel version of Model 2. Instead of growth over the long run, we consider several shorter periods of time and then pool them with a panel estimator, in this case, fixed effects. The interpretation of these models is a bit *ad hoc* when compared to Models 1 and 2 because the notion of steady state is absent. Such models are generally just referred to as "growth regressions" (see, for example, Burnside and Dollar 2000). In our case, we are interested in estimating the short-term growth effects of a civil war and testing the extent of their persistence. The panel setup is particularly appealing because we can add lagged values of the civil war terms to examine the persistence.

Building on the previous models, Model 3's specifications are based on:

$$\ln(y_{it}) - \ln(y0_{it}) = \varsigma_0 + \varsigma_1 \ln(y0_{it}) + \varsigma_2 \ln(\text{invest}_{it}) + \varsigma_3 \ln(n_{it} + g + \delta)$$
$$+ \varsigma_4 \ln(s0_{it}) + \tau_t + \eta_i + \varepsilon_{it} \,, \tag{13}$$

where τ_t is a period-specific effect and η_i is a country-specific effect. The time subscript in this model denotes the periods over which growth is computed. We look at five-year intervals from 1960-90, thus giving six periods (t = 1,2,…,6). The $y0_{it}$ and $s0_{it}$ variables denote the values for income per capita and schooling, respectively, at the beginning of the period; y_{it} is the value of income per capita at the end of the period; and the other variables (invest_{it} and n_{it}) are averaged over the years within each period. The time and cross-sectional components may be captured in various ways including fixed effects (or dummy variables), random effects, or additional time and country-specific measures.

The three models allow us to study the macroeconomic effects of civil wars in a general fashion. Model 1 is a cross-sectional regression that addresses the question of the long-run impacts of civil wars on income per capita, in which 1985 is assumed to represent a steady state. A negative coefficient on the civil war variables in Model 1 indicates that nations, which experience civil wars, either directly or via proximity to other civil wars, suffer a lower steady-state level of income per capita. Even though two nations may have similar initial conditions, population growth, and investment profiles, they could end up at different steady states as a result of civil wars.

Model 2 facilitates an assessment of the *transition* to a steady state. As with Model 1, it is a cross-sectional regression, but the dependent variable concerns the growth in income per capita from the initial period until the steady state. A negative coefficient on the civil war variables in this model suggests that the growth rate to steady state is reduced as a result of civil wars. This model should confirm the findings from Model 1 in that lower growth rates lead to lower values of income per capita.

Both Models 1 and 2 have long-run (i.e., steady-state) interpretations, whereas Model 3 concerns shorter periods of economic growth and is, perhaps, the most appealing empirical model because of the time-series component. A negative coefficient on the civil war variables in this model indicates that short-term growth is adversely affected by such internal conflicts. When these short-term effects persist, there should be such evidence in Model 1. In Model 3, we can test for the persistence directly by entering time lags of the civil war variables. Because there are six five-year periods starting at 1960, we utilize the civil war terms starting in 1955 to enter one-period lags. By comparing models with and without country dummy variables, we can ascertain the potential magnitude of the specification error due to left-out country-specific variables; this provides added confidence in the effects attributed to the civil war variables.

RESULTS

Several variations of Model 1 are presented in Table 3. The first variation is a benchmark to which we add elfo and the civil war variables. In terms of the classical determinants of growth (invest, $n + g + \delta$, and s_ave), our results are consistent with the theory and the estimates presented by Mankiw, Romer, and Weil (1992, 420, Table II). When compared to Mankiw, Romer, and Weil, differences in the point estimates are not unexpected, owing to some differences in PWT 5.6 and a different variable for human capital. There is mixed evidence for the notion that civil wars within a country and in its neighbors influence the equilibrium growth path. The civil war indicators (civ and w_civ) are not significant , although they do exhibit the anticipated negative relationship. Variations (3) and (4) indicate that duration in neighbors (w_tmonths) and severity at home (tdeaths) are significant and negative in separate regressions.

The distributions of the civil war variables are somewhat bimodal (see Appendix); i.e., there are numerous zeros, a few smaller values, and then quite a few larger values, especially in the tdeaths measure. With such data, it is possible that the effect on income per capita is not linear; thus, we define a new dummy variable (deathdum) that equals one in countries where the civil war battle deaths exceed 25,000 over the sample period (1960-85). The qualitative effect from this variable [variation (5)] is similar to the duration variable with significant effects only in the spatial term.

As mentioned above, it is not theoretically clear how to enter the spatial variables to gauge the impact of a civil war. A case could be made for including them in the labor and depreciation term [$\ln(n+g+\delta)$] as a proxy for migration or a shock to labor growth. A case could also be made for interacting the spatial terms with the schooling variable, because the impact of migration and civil war casualties could change the level of human capital in the home country. We tested for both of these possibilities using Model 1, and we found no statistical evidence that civil wars in neighboring countries impacted the human capital or labor terms. In the case of human capital, the tests consist of straightforward nested tests of the interaction term. The test for population is more complex insofar as the spatial terms enter the model nonlinearly through $\ln(n+g+\delta)$. A nonlinear joint test was implemented as follows. First, we assumed that the civil war variable under consideration is civ. Next, we estimated

$$\ln(y85_i) = \gamma_0 + \gamma_1 \ln(\text{invest}_i) + \gamma_2 \ln(n_i + g + \delta + \theta \text{w\_civ}_i) + \gamma_3 \ln(\text{s\_ave}_i) + \gamma_4 \text{civ}_i + \gamma_5 (1-\theta)\text{w\_civ}_i + \varepsilon_i , \quad (14)$$

and considered the significance of θ. When θ is zero, the spatial lag enters linearly as a country-specific effect, and, when θ is one, the spatial lag takes on the migration interpretation within the population term. Other values of θ suggest two avenues for the effects of civil wars in neighboring countries: one through migration and one direct effect, perhaps through disruption or uncertainty from the civil war spillovers. We estimated equation (14) for each of the civil war variables and always found that the estimate on θ was not significantly different than zero. Based on both sets of tests [interactions with human capital and equation (14)], we conclude that the observed negative effects of civil wars in neighboring countries result from factors such as uncertainty and direct disruption of economic activity rather than from the dilution of the population's human capital or enhanced population growth rate due to migration.

The magnitude of the civil war effects is evident from the coefficient estimates. For example, the point estimate on w_tmonths and tdeaths in variation (3) in Table 3 is –0.409 per 100 or –0.00409 per month. The dependent variable is the natural logarithm of GDP per capita which has an average of approximately 7.85 or $2565 in levels, so that a one-month increase in the spatial average of civil war months (w_tmonths) results in a decrease in per-capita GDP of about $10.00 (0.4%). Based on the standard error of the estimate, the 95% confidence interval (+/– two standard errors) is approximately $0.00 to $20.00 per capita. Similarly, for tdeaths (which is scaled by 1 million) an increase in tdeaths decreases per-capita GDP by about $10.00. These effects are not large and, coupled with the mixed statistical evidence, suggest that the long-run effects of civil wars are rather modest. In contrast, severe civil wars in neighboring counries are associated with substantial effects on income per capita. Based on variation (5) in Table 3, the estimate on w_deathdum is –0.527, so that income per capita is approximately 41% ($=e^{-0.527} - 1$) smaller in a country whose neighbors are burdened with a severe (>25,000 battle deaths) civil war. Thus, neighborhood influences may be very significant.

The estimates of Model 2 are available at *http://www.bruton.utdallas.edu* and generally confirm the findings in Table 3. Of the civil war variables, only the civil war indicator (civ) and the severity indicator (deathdum) are significant at the 0.10 level. The remaining variables are generally as expected with strong evidence of conditional convergence and growth returns to physical investment. Convergence indicates the ability of a nation to recover following a war. In summary, Models 1 and 2 indicate some modest negative impacts stemming from civil wars at home and abroad. Given that both models are long run, there is a need to examine carefully the short-run influences via Model 3.

Looking at equation (13), we see that there are various ways to approach the estimation. One (e.g., Burnside and Dollar 2000) is to pool the period observations, so as to capture the time and country-specific effects (τ_t and η_i) with a limited set of independent variables that vary over countries and/or time. The advantage of this approach is that the pooling increases the variability in the independent variables and, therefore, the power of the model to discriminate among the hypothesized effects. The drawback is the failure to measure all of the important influences. A second approach (e.g., Forbes 2000) is again to pool the period observations, but to use fixed or random effects for τ_t and η_i. The advantage of this approach is that the worry about left-out time or country-specific effects is eliminated, but there are serious econometric issues with this approach that arise because ln($y0_{it}$) is an independent variable (see Bond, Hoeffler, and Temple 1999; Caselli, Esquivel, and Lefort 2000; and Levine, Loayza, and Beck 2000).[10] Because our concern is with identifying the effects of civil wars on economic growth, we estimated equation (13) with several different estimators to check their sensitivity on the civil war variables. Fortunately, our main conclusions about the short-run effects of civil wars at home and in neighbors are robust with respect to the estimation method. For discussion purposes, we present (see Table 4) the results from pooling without country fixed effects and briefly identify the differences in the coefficient estimates that arise with the inclusion of country fixed effects. The full fixed-effects estimates obtained using various econometric estimators are available at *http://www.bruton.utdallas.edu*.

In Table 4, the regressions are from panel estimation with six five-year time periods, so that the dependent variable is the five-year growth in per-capita GDP. The time-wise fixed effects are not displayed to conserve space, while the ethno-linguistic fractionalization index (elfo60) is included as a country-specific effect. The "benchmarks" are displayed as variations (1) and (3), while variations (2) and (4) expand the specification by including the time lags of the respective civil war variables. The results for duration (tmonths) are similar to those with civ and are suppressed. In Table 4, variables *y*0 and invest are significant and of the expected sign, while *s*0 and elfo are insignificant, owing to the inclusion of the initial value of per-capita GDP. In contrast to the results with country-specific fixed effects, the labor term, $(n + g + \delta)$, is not significant in this specification. The magnitude of the coefficient estimate on ln(*y*0) is quite sensitive to the inclusion/exclusion of country fixed effects; however, the coefficient is always negative and significant at, at least, the 0.05 level.

The estimates of the civil war coefficients generally support the notion of a short-term negative effect. In the first regression, the civil war indicator is highly significant and quite large, considering that the growth is computed over a five-year interval. The spatial effect, however, is insignificant. Somewhat surprisingly, the total deaths measure is insignificant in variation (3), but this measure in neighboring countries is highly significant. Given the strength of effects in variation (1), we expected a significant coefficient of tdeaths, and attribute its absence to an inappropriate functional form in this variable, rather than the lack of an effect. However, we did not undertake *ad hoc* functional form searches.

As seen in the results on the lagged variables [variations (2) and (4)], there is little evidence of significant lagged effects in civ. The same result holds for the duration measure, tmonths, which is not reported. Only the lag of w_tdeaths is statistically significant. This finding supports the notion that the influence of civil wars is confined to short-term economic growth. A civil war in (say) period 2 reduces the *y*0 in period 3 and putting *y*0 in the model seems to capture all of the effects from the previous civil war; i.e., the *autonomous* effects do not last beyond the current period.

As a whole, the estimations of Models 1, 2, and 3 suggest that civil wars have a *consistent* and *strong* negative effect on short-term growth rates but not on longer-term growth rates or on steady-state values of per-capita GDP. How can we explain these seemingly contradictory findings? Actually, they are consistent with neoclassical economic theory. Recall that the theory predicts that nations with lower per-capita incomes grow faster than nations with higher incomes, *ceteris paribus* – i.e., conditional convergence. We find that a civil war (either within a nation or in its neighbors) reduces economic growth for a short period of time. Thus, income per capita is lower than it otherwise would be after the civil war. Since nothing seems to have happened to the economic fundamentals due to the war (investment, population growth rates, human-capital accumulation), the country must experience *faster* economic growth following the civil war. Indeed, we always find a negative and significant effect on the initial values of income per capita. If civil war had significantly altered the fundamental economic relationships, then we should have seen the effects in our lagged variables and in our tests with Model 1 (interactions with human capital and migration in the population term).[11]

CONCLUDING REMARKS AND POLICY IMPLICATIONS

The primary purposes of this paper is to analyze how much a civil war, either at home or in a neighboring state, affects short- and long-run growth as well as the long-run steady-state level of income per capita. The empirical findings support our intuition that the countries most at risk from collateral damages stemming from neighboring civil wars were those with longer contiguous borders with nations in civil conflict. Moreover, we found that civil war created a significant *negative influence on short-run growth* within the country and its neighbors. There was less clear-cut evidence of a negative impact of civil wars on long-run growth when measured over a twenty-five year period, which is probably due to the short-run nature of many civil wars, so that their short-run impact is diluted by convergence.

The presence of neighborhood effects means that foreign assistance and other policy decisions to counteract the harmful consequences of a civil war must be directed to the host country *and some of its neighbors*. Given the magnitude of these spillover effects, required assistance in neighboring countries may be as important as in the conflict-ridden country itself. These civil war influences should be addressed quickly, because such factors are immediate and can lead to reduced standards of living in the short- and long-run. Since those neighbors most at risk are those with longer common borders, our results point to where policymakers should be most vigilant in counteracting the consequences of civil war spillovers. Foreign assistance should not be focused on the labor market or offsetting the influence of migration, because civil wars affect the growth of neighboring countries more through general contagion than through population or human capital factors. Both the death rate and the duration of the conflict influence the extent of the negative neighbor spillovers on short-run growth. However, the death rate has a stronger influence, which indicates that the world community must address such conflict before the carnage is too great. In terms of peacekeeping, the world community needs to mobilize sufficient peacekeeping efforts to contain the economic contagion stemming from civil wars.

The pooled estimates of short-run growth showed the importance of the initial income per capita level and the unimportance of schooling. Given the importance of this convergence term, countries most devastated by civil wars are anticipated to rebound the quickest. Schooling was a more significant determinant of the long-run level of income per capita than its growth, thus suggesting that schooling is still an important consideration even though its influence on growth was not quite significant.

There are a number of avenues of future research to pursue regarding the impact of civil wars on economic growth and long-run income per capita. First, with updated data to 1999, there should be sufficient data to do region-specific panel estimates on ascertaining civil wars' effects on short-run growth for Africa, Asia, and Latin America. Second, such analyses can lead to cross-regional comparisons that can isolate not only different regional reactions, but also identify factors responsible for such differences (i.e., the number and severity of civil wars, or geographical differences). Third, the analysis can be broadened to include foreign aid so that the positive effects of aid are put in perspective with the negative effect of civil wars. It would also be useful to test for any interaction between foreign aid and civil wars to see if such aid can have the unintended consequence of fueling such conflicts. Fourth, a simultaneous-equation approach can be applied so that a spatial probit analysis is combined with a growth equation to determine the mutual dependency, if any, between the probability of civil war and economic growth.

Footnotes

1. An externality is an uncompensated interdependency, in which the actions of one agent creates costs (benefits) for another agent (Cornes and Sandler 1996, chapter 3).

2. A steady-state equilibrium is reached when key variables maintain their value from one period to the next.

3. A neoclassical production function also assumes the satisfaction of the Inada conditions, where the marginal product of the alternative forms of capital approaches zero (infinity) as time goes to infinity (zero) (Aghion and Howitt 1998).

4. In interesting and useful work on civil wars, Collier (2000), Collier and Hoeffler (1999, 2000) base their analysis on comparative statics and do not explicitly examine investment or growth dynamics. These authors investigate alternative influences of greed (for national resource wealth) or grievance on the likelihood of a civil war. The impact of a civil war on economic growth, investment, and external indebtedness is, however, studied by Elbadawi and Ndung'u (2000), but unlike our analysis, they do not examine neighbor effects. Doyle and Sambanis (2000) examine peacebuilding in civil wars.

5. For more details, see Mankiw, Romer, and Weil (1992) or an earlier version of this paper, available from *http://www.bruton.utdallas.edu*.

6. Once again, consult Mankiw, Romer, and Weil (1992) for derivation.

7. See Mankiw, Romer, and Weil (1992, 423) and Barro and Sala-i-Martin (1992, 225). In essence, we are assuming that:

$$d \ln y(t)/dt = \lambda[\ln y^* - \ln y(t)].$$

8. In Elbadawi and Sambanis (2000) and Collier, Hoeffler, and Soberdom (1999), elfo is shown to be a nonmonotonic determinant of the duration of a civil war. Civil wars are difficult to begin in a homogenous society and difficult to sustain in a greatly fractionalized society.

Thus, there appears to be an optimal heterogeneity for sustaining a civil war. A couple earlier studies also examine how fractionalization raises the likelihood of a civil war (e.g., Elbadawi and Sambanis 2002 [this issue]). We use elfo as a determinant of income per capita.

9. Gleditsch and Ward (2000) also apply spatial statistics to the study of conflict. Unlike our analysis, these authors are interested in the influence that contiguity to other interstate wars has on the likelihood of a nation becoming embroiled in war. Additionally, a country's political system – democracy or autocracy – is related to this probability.

10. We thank Anke Hoeffler and Norman Loayza for their help in identifying these issues in an earlier draft of this paper.

11. We looked for direct evidence that civil war negatively impacts investment by estimating panel versions of investment share equations (see, e.g., Barro 1991, 425-28). The civil war terms were never significant in these models, a result that is not inconsistent with the findings presented above.

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TABLE 1
Variable Names, Descriptions and Sources for the Raw Data

Variable	Description	Source
y*xx*	Real GDP per capita in constant dollars in year *xx*	Penn World Table 5.6[a]
pop*xx*	Population in 000's in year *xx*	Penn World Table 5.6[a]
i*xx*	Real investment share of GDP	Penn World Table 5.6[a]
sxx	Percentage of "secondary school attained" in population older than 25	Barro and Lee (1996)[b]
deaths*xx*	Deaths per month from civil wars in year *xx*	Singer and Small (1993)[c]
months*xx*	Months of civil war in year *xx*	Singer and Small (1993)[c]
elfo*xx*	Ethno-linguistic fractionalization: The probability that two randomly selected persons do not speak the same language in year *xx*	Sambanis[d]

a. *http://pwt.econ.upenn.edu*
b. *http://www.worldbank.org/research/growth/ddbarle2.htm*
c. Correlates of War Project: International and Civil War Data, 1816-1992.
d. Personal correspondence. Original source is Bruk and Apenchenko (1964). Only measured in 1960.

TABLE 2
Variable Names and Descriptions for the Derived Data

Variable	Description
ln(•)	Denotes natural logarithm
lag(•)	Denotes a time lag of one period
invest	Average share of investment over the relevant sample period
s_ave	Average of s*xx* over the relevant sample period
civ	Civil war dummy, equal to one if months*xx* is greater than zero during any years of the sample period
tdeaths	Total deaths from civil war during the relevant sample period
tmonths	Total months of civil war during the relevant sample period
deathdum	Death dummy, equal to one if tdeaths is greater than 25000
w_civ	w•civ: The "spatial average" of civ, indicating civil wars in neighboring countries over the relevant sample period
w_tdeaths	w•tdeaths: The "spatial average" of tdeaths, indicating the deaths from civil war in neighboring countries over the relevant sample period
w_tmonths	w•tmonths: The "spatial average" of tmonths, indicating the total months of civil war in neighboring countries over the relevant sample period
w_deathdum	w•deathdum: The "spatial average" of deathdum, indicating more severe civil wars in neighboring countries over the sample period
period*x*	Time period dummy, equal to 1 if period*x* and zero otherwise

NOTE: The relevant sample period varies by model. In Models 1 and 2, it is from 1960 to 1985. In Model 3, we have seven 5 year periods; 1956-1960, 1961-1965, 1966-1970, 1971-1975, 1976-1980, 1981-1985, and 1986-1990.

TABLE 3
Model 1 Regressions. Dependent Variable is ln(*y*85). White's Robust Standard of Errors in Parentheses. Number of Observations = 83.

Independent	Model 1 Variations				
Variables	(1)	(2)	(3)	(4)	(5)
ln(invest)	0.629 ***	0.576 ***	0.600 ***	0.609 ***	0.571 ***
	(0.14)	(0.12)	(0.12)	(0.12)	(0.12)
$\ln(n + g + \delta)$	–2.852 ***	–2.242 ***	–2.135 ***	–2.162 ***	–2.133 ***
	(0.61)	(0.66)	(0.65)	(0.68)	(0.64)
ln(s_ave)	0.219 **	0.177 **	0.183 **	0.191 **	0.180 **
	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
elfo60		–0.770 ***	–0.740 ***	–0.670 ***	–0.734 ***
		(0.28)	(0.28)	(0.29)	(0.27)
civ		–0.217			
		(0.17)			
w_civ		–0.050			
		(0.20)			
tmonths			–0.258		
			(0.27)		
w_tmonths			–0.409 **		
			(0.20)		
tdeaths				–0.463 **	
				(0.21)	
w_tdeaths				–0.060	
				(0.40)	
deathdum					–0.326
					(0.21)
w_deathdum					–0.527 **
					(0.25)
constant	1.173	3.071	3.395	3.281	3.370
	(1.66)	(1.82)	(1.78)	(1.87)	(1.77)
R-square	0.62	0.67	0.61	0.62	0.61

NOTE*:* The variables elfo60, tmonths, w_tmonths, and tdeaths are scaled by 100 for presentation.
** Indicates significant at the 0.05 level.
*** Indicates significant at the 0.01 level.

TABLE 4

Model 3 Regressions. Pooled Estimates of the Six-Period Model. Dependent Variable Is $\ln(y) - \ln(y_0)$. White's Robust Standard Errors in Parentheses. Number of Observations = 489.

Independent	Model 3 Variations			
Variables	(1)	(2)	(3)	(4)
ln(y0)	–0.029 **	–0.027 **	–0.027 **	–0.027 **
	(0.01)	(0.01)	(0.01)	(0.01)
ln(invest)	0.061 ***	0.061 ***	0.065 ***	0.068 ***
	(0.01)	(0.01)	(0.01)	(0.01)
$\ln(n + g + \delta)$	–0.108	–0.115	–0.096	–0.105
	(0.08)	(0.08)	(0.08)	(0.08)
ln(s0)	0.733	0.703	0.833	0.698
	(0.58)	(0.58)	(0.58)	(0.58)
elfo	–0.047	–0.045	–0.043	–0.048
	(0.03)	(0.03)	(0.03)	(0.03)
civ	–0.073 ***	–0.073 ***		
	(0.03)	(0.03)		
w_civ	–0.018	–0.013		
	(0.02)	(0.03)		
lag(civ)		–0.036		
		(0.03)		
lag(w_civ)		0.023		
		(0.02)		
tdeaths			0.858	0.917
			(0.73)	(0.71)
w_tdeaths			–0.286 ***	–0.303 ***
			(0.09)	(0.10)
lag(tdeaths)				–1.257 ***
				(0.40)
lag(w_tdeaths)				0.183
				(0.07)
constant	–0.025	–0.043	0.017	0.001
	(0.21)	(0.21)	(0.21)	(0.21)

NOTE: The six periods are 1961-65, 1966-70, 1971-75, 1976-80, 1981-85, and 1986-90. The lag values in period 1 are based on 1956-60. The dependent variable for period 1 is ln(y65) – ln(y61) and the value for y0 is y60. All other periods are constructed in a similar fashion. Each regression also contains a dummy variable for period. The variable elfo, ln(s0), and tdeaths are scaled by 100 for presentation.

** Indicates significant at the 0.05 level.

*** Indicates significant at the 0.01 level.

APPENDIX
Civil War Raw Data

COUNTRY	CIV	TMONTHS	TDEATHS	W_CIV	W_TMONTHS	W_TDEATHS
ALGERIA	1	6	0.15	0	0	0
BENIN	0	0	0	0	0	0
BOTSWANA	0	0	0	0	0	0
CAMEROON	0	0	0	0	0	0
CENTRAL AFR.R.	0	0	0	0	0	0
CONGO	0	0	0	0.73	48.25	7.92
GABON	0	0	0	0	0	0
GAMBIA	0	0	0	0	0	0
IVORY COAST	0	0	0	0	0	0
KENYA	0	0	0	0	0	0
LESOTHO	0	0	0	0	0	0
MADAGASCAR	0	0	0	0	0	0
MALAWI	0	0	0	0	0	0
MAURITANIA	0	0	0	0.17	1.03	0.03
MOROCCO	0	0	0	1.00	6.00	0.15
MOZAMBIQUE	1	74	9.49	0	0	0
NIGER	0	0	0	0.55	22.57	0.25
NIGERIA	1	33	101.10	0.02	1.48	0.01
RWANDA	1	3	0.25	1.00	27.11	7.14
SEYCHELLES	0	0	0	0	0	0
SOMALIA	1	44	2.90	0	0	0
SWAZILAND	0	0	0	0.20	14.52	1.86
TANZANIA	0	0	0	0.53	21.38	3.55
TOGO	0	0	0	0	0	0
TUNISIA	0	0	0	1.00	6.00	0.15
UGANDA	1	63	7.10	0.50	25.68	4.12
ZAMBIA	0	0	0	0.76	62.92	10.55
ZIMBABWE	1	85	1.22	0.40	29.71	3.81
CANADA	0	0	0	0	0	0
DOMINICAN REP.	1	5	0.31	0	0	0
EL SALVADOR	1	77	1.28	0	0	0
GUATEMALA	1	142	12.54	1.00	77.00	1.28
HAITI	0	0	0	1.00	5.00	0.31
HONDURAS	0	0	0	1.00	104.83	6.10
NICARAGUA	1	65	4.65	0	0	0
PANAMA	0	0	0	0.41	23.11	2.91
PUERTO RICO	0	0	0	0	0	0
TRINIDAD&TOBAGO	0	0	0	0	0	0
U.S.A.	0	0	0	0	0	0
ARGENTINA	0	0	0	0	0	0
BOLIVIA	0	0	0	0	0	0
BRAZIL	0	0	0	0	0	0
COLOMBIA	1	57	7.19	0	0	0
ECUADOR	0	0	0	1.00	57.00	7.19
GUYANA	0	0	0	0	0	0
PARAGUAY	0	0	0	0	0	0
PERU	1	45	0.80	0.42	23.82	3.00
SURINAME	0	0	0	0	0	0
VENEZUELA	0	0	0	0.41	23.40	2.95
BANGLADESH	0	0	0	0	0	0

CHINA	1	20	5.00	1.00	182.00	2.58
HONG KONG	0	0	0	1.00	20.00	5.00
INDIA	1	6	0.12	0.54	37.53	2.32
INDONESIA	1	12	0.73	0	0	0
IRAN	1	26	2.10	0	0	0
IRAQ	1	11	0.11	1.00	26.00	2.10
ISRAEL	0	0	0	0	0	0
JAPAN	0	0	0	0	0	0
KOREA, REP.	0	0	0	0	0	0
MALAYSIA	0	0	0	1.00	12.00	0.73
MYANMAR	1	182	2.58	0	0	0
NEPAL	0	0	0	1.00	11.91	2.18
SAUDI ARABIA	0	0	0	1.00	6.28	0.09
SINGAPORE	0	0	0	0	0	0
SRI LANKA	1	30	0.56	0	0	0
SYRIA	0	0	0	0.93	6.66	0.09
TAIWAN	0	0	0	0	0	0
THAILAND	0	0	0	0.78	142.06	2.02
AUSTRIA	0	0	0	0	0	0
BELGIUM	0	0	0	0	0	0
CZECHOSLOVAKIA	0	0	0	0	0	0
DENMARK	0	0	0	0	0	0
FINLAND	0	0	0	0	0	0
FRANCE	0	0	0	0	0	0
GERMANY, WEST	0	0	0	0	0	0
GREECE	0	0	0	0	0	0
ICELAND	0	0	0	0	0	0
IRELAND	0	0	0	0	0	0
ITALY	0	0	0	0	0	0
LUXEMBOURG	0	0	0	0	0	0
MALTA	0	0	0	0	0	0
NETHERLANDS	0	0	0	0	0	0
NORWAY	0	0	0	0	0	0
SWITZERLAND	0	0	0	0	0	0
U.K.	0	0	0	0	0	0

NOTE: TMONTHS and TDEATHS are calculated for the 1960-85 period.